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PRODUCT ENGINEERING

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The New Bearing Alloys—Gear Materials and Their Heat-Treatment—Steel Castings for Welded Designs—Properties of Die-Casting Alloys—Color With Plastics

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Mechanical Design • Product Development

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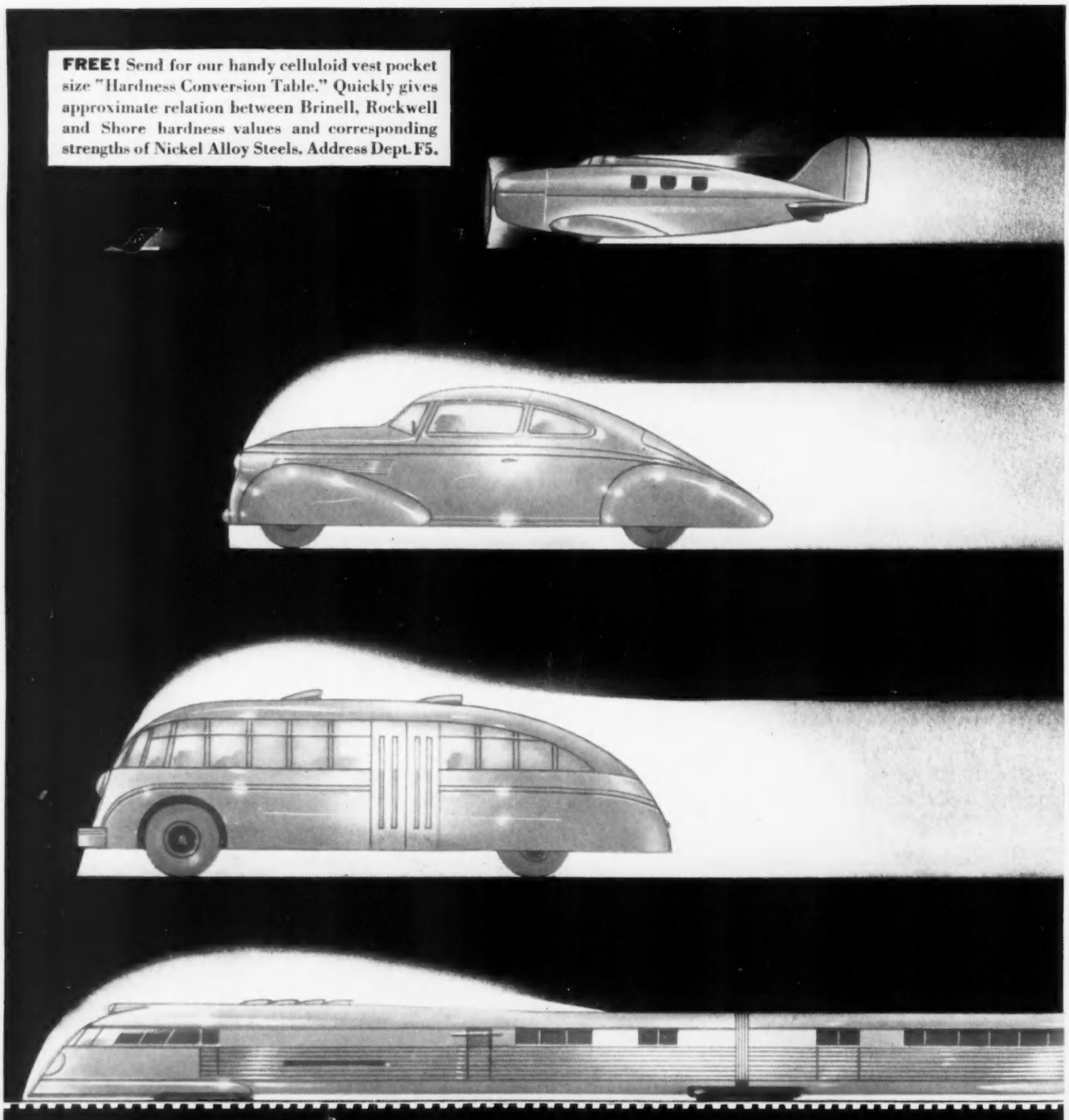

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PRODUCT ENGINEERING

VOLUME 6 NUMBER 10

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November Number

In 32 pages or more will be presented the results of our 1935 survey of trends in product development. Charts, curves, tabulations and pictures will help tell the story. Thus will November *Product Engineering* be the 1935 encyclopedia of current practice and trends in the design of machinery and other products.

What have been the significant developments in parts and materials over the past year? What are the design possibilities when the engineer uses these improved parts and materials? What are the design trends?

More than 400 chief engineers and engineering executives have filled out our questionnaire form, giving the answers to these and many more questions. More than 100 engineers have been interviewed.

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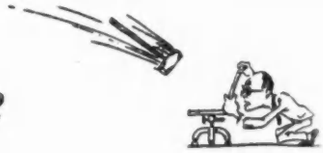
Intimate Correspondence



More On Variable Speed

PRODUCT ENGINEERING
NEW YORK

In your September number, beginning on page 339 you have an article "Variable-Speed Drives in Modern Machines." Presumably this article is supposed to include the latest in the application of variable-speed drives. But I noticed that the article did not include anything about the New Departure Transitorq which, incidentally, is advertised in your paper. At the Machine Tool Show I saw a number of lathes and other machine tools with the Transitorq built-in.

Nor does the article make any mention of hydraulic variable-speed drive units such as recently announced by Vickers. —B.C.L.
Cincinnati, Ohio

WE must humbly acknowledge that it is not always possible to include "the latest" in our articles. Things are moving so fast these days that the ink is hardly dry before something new is introduced.

As to our omission of any mention of the Transitorq in our September issue, at the time the article was prepared we were unable to find any machinery manufacturers who were willing to release the information relative to their application of the Transitorq. Naturally the machine tool builders were withholding their releases until the Cleveland Show.

As to the hydraulic variable-speed units, these will make an article by themselves which will appear in a future issue. Similarly, there will be an article on the motorized units such as the Transitorq.

Old But Still Interesting

PRODUCT ENGINEERING
NEW YORK

In the June 1930 issue of your publication you had some cuts showing various mechanical movements.

If you have a copy of this issue available, or any other issues containing these mechanical movements, we will appreciate a copy of same. If you will let us know how much this will be, we will be glad to forward you our check for same. —R.H.S.H.
Baltimore, Md.

THE pictures referred to are those showing 160 working models of mechanical motions classified in ten panels, and which appeared in the June and July 1930 numbers of *Product Engineering*. The working models were designed and built by W. M. Clark, and were exhibited at the Newark Museum, Newark, N. J.

Because of the great demand for these pictures, they were reprinted in a four-page leaflet. A limited number of these reprints are still available and can be had for the asking.

Not a Trade Paper

PRODUCT ENGINEERING
NEW YORK

It is my impression that *Product Engineering* does not deal very much with the line of products that my company manufactures, namely, valves and plumbing specialties. However, I will be glad to have more information in this respect. —R.H.B.
New Britain, Conn.

OUR correspondent is both correct and incorrect. It is true that *Product Engineering* **is not a trade paper.** Hence the absence of any comprehensive editorial matter detailing the business activities in any one field. Being a professional publication, the editorial content confines itself to engineering principles that have broad application. For example, recent articles on die-castings, thermostatic devices and springs, to mention only a few, contain data and information applicable to the design of valves, fittings and plumbing specialties.

Let's Start Something

PRODUCT ENGINEERING
NEW YORK

I find your magazine brings together a very broad group of subjects helpful to most design engineers. It succeeds in reviewing new developments in all fields, which is an excellent service.

There is one other type of service I wish your organization would furnish. That is to develop for the engineering office a standard filing system similar to that of the American Institute of Architects. Such a system I believe should be general to serve those in general practice, then tie into this a more detailed system for the various specialized branches such as aeronautical, automotive, chemical, civil, electrical, marine and mechanical, etc. With but little encouragement manufacturers would add to their standard size literature (8½x11) filing numbers placed in an appropriate location.

Although this subject may not be one which *Product Engineering* could carry on as a magazine, there is centered in your publishing company the necessary group experience to cooperate with the various technical groups and societies to develop a very comprehensive system.

May I have your comment. —O.G.B.
Dearborn, Mich.

WE'LL "pass the buck" right over to the reader. Here are two problems tied up in one. With reference to standard filing systems, the Engineering Societies Library has developed a variation of the decimal system to meet their special needs. But the system that O.G.B. evidently has in mind would have to go far beyond the filing and indexing of technical articles and information.

With reference to standard sizes of catalogs and bulletins, this matter has cropped up time and again. The Simplified Practices Division of the American Bureau of Standards has accomplished something in reducing the number of paper sizes in use. But little or no progress has been made in standardizing the sizes of catalogs and bulletins. On the other hand, considerable has been accomplished in this direction in Germany.

In so far as the American Standards Association is concerned, they undertake standardization programs only at the request of interested parties. If there is sufficient demand for a particular standardization, the work of developing the standards is supervised by the Association.

Hence we ask the question: Is there a real need for a standardized filing system for engineering departments, and is there a real need for the standardization of catalog sizes? We know the answer but wonder how many responsible engineers are sufficiently interested to make their desires known. We suggest that those who are interested should write us about it. *Product Engineering* will be glad to serve as a medium to call this to the attention of the standardizing bodies.

Surface Finish Specifications

PRODUCT ENGINEERING
NEW YORK

We are very glad to note that you are planning to have another artcile in your magazine on the subject of the specification of surface finish. We would like to gather as much information as we can, as we feel here is one subject that causes a lot of trouble because finish cannot be specified definitely on drawings.

Incidentally, the pamphlet published by the American Standards Association on drawing practice is a very good one, and we have already purchased several copies. —B.F.H.
New Freedom, Pa.

OUR news item relative to the recently published Drawing and Drafting Room Standards, issued by the American Standards Association impelled quite a few of our readers to get this valuable pamphlet. We highly recommend it and hope that many others of our readers will follow the example of B.F.H. As to an article on surface finish designation, this is on the books and will appear in an early issue.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. OCTOBER 1935 VOLUME SIX, NUMBER TEN

Croesus and His Gold

CROESUS was proud of his gold; no other man possessed as much as he. His was the conceit and arrogance born of wealth. With much ceremony and ostentation he showed his golden treasures to the philosopher Solon, who wisely remarked, "If any other come who hath better iron than you, he will be master of all this gold." Croesus became humble as he realized the truth of this statement and what it implied.

Damascan swords, Roman armor and cast-iron cannon at Cressy demonstrated that outnumbered armies are usually victorious if their military equipment is sufficiently better than that of their opponents. And the possession of gold serves merely as an added incentive for the adversary, raising his hopes and morale and impelling him to redouble the efforts of his onslaughts. The more coveted the prize of victory, the greater is the determination to win.

History as it is written and taught is mostly a record of bloody conflicts, of lives of men ambitious for personal power and glory, and the stories of nations either despairing under oppression, ruthlessly oppressing the vanquished or seeking to dominate the world. But the history of the growth of the material civilization is the history of the development of chemistry and metallurgy, not as reflected in the powers of military conquests, but as it has brought the comforts and luxuries made available by the products of today.

One is likely to overlook the predominant part played by materials in the history of the development of civilization. No machine can be better than the material of which it is made. Those materials available at the time will fix the limits of power, efficiency, and dependability of operation to which the machine can be designed. Mechanical design is always restricted by the properties of the materials of construction used.

In its operating principles, the automobile engine of today is the same as Dr. Otto's first engines. Without the superior modern materials, the modern internal combustion engine would still be much the same. Steamships, automobiles, airplanes and all other machinery similarly demonstrate how improved mechanical design had to wait on the metallurgist to make possible the better product.

WHEN studying the developments of a decade or more, one is impressed by the fact that the better machine was the result of using better material. But this is not so apparent in watching the day-to-day or week-to-week developments. One is likely to lose sight of the cumulative improvements attainable through the use of a more suitable, though perhaps more expensive, material. And it must be kept in mind that the increased cost per pound may be more than offset by less material being required, more economical construction, or by the increased salability of the product.

But the best material for a given purpose is not necessarily the most expensive. Price per pound is not fixed by a formula the variables of which are physical and chemical properties. For military armaments iron is more valuable than gold, and thus we return to Solon and his philosophical remark.

Solon's remark might well be interpreted figuratively. Gold is the reward for capturing the market with a product, and iron is the material of which the product is made. "If any other come which is made of better materials, it will be master of all this market."

BEARING METALS for Severe Service—I

MANY claims have been made for the new types or new forms of bearing metals made available during the past year or two. Some of these claims have not materialized; in some instances expectations were based on incomplete knowledge of the material as a bearing metal. Even today, as the research engineer of one bearing manufacturer expressed it, "the designer, the bearing manufacturer and the oil producer are in a three-way controversy in regard to the benefits to be derived from the new bearing metals."

No one material is best for all bearing applications. Each of the new alloys excells in certain properties, and thus, like all other materials, each bearing material has definite limitations that influences the design.

Standard bronzes and babbitts have not been displaced by the newer bearing metals for "normal" service conditions. But, where unit bearing loads, operating temperatures, rubbing speeds or pounding loads are extremely high, as in airplane and automobile engines, in high speed diesels and in rolling mill machinery, crushers and centrifugals, the new alloys have distinct advantages. In this symposium and the concluding installment to appear in the December number, the properties and applications of the new bearing metals are explained, and some of the design limitations in the use of these materials are discussed.

▼ ▼ ▼

Bearing Requirements In Automobile Engines

V. SKILLMAN
Detroit Aluminum & Brass Corporation

EARLY developments in the automobile industry resulted in the elimination of the solid babbitt bearings and the improvement of the bronze-back babbitt-lined type. These answered the requirements for some years until the World War brought the development of the Liberty motor for aircraft, and then it was soon found that changes in design and better bearings were needed. From research and investigation undertaken under pressure of war needs, bearings were so improved that they were no longer the limiting factor in the satisfactory performance of this engine.

This period of development contributed two outstanding improvements in motor bearings. One was the centrifugal casting of babbitt in the bronze-backed bearings, and the other was the introduction of interchangeable bearings to speed production and servicing by eliminating hand fitting. Although developed to meet aviation requirements, the automotive industry speedily adopted the improvements. The interchangeable bearing is still used in all large production motors, and until recently nearly all babbitt-lined bearings were cast centrifugally.

The next important change in bearings again came through aviation with the development of the air-cooled radial engine in which bearing pressures and temperatures were higher, and periods of service longer. For greater rigidity steel was substituted for the bronze backs formerly employed. The centrifugally cast babbitt lining, which had been becoming thinner year by year, was further decreased in thickness. Satisfactory bearings of this type were produced, and the need was partially met for a time. However, the temperature at which babbitt rapidly loses its hardness and strength was being exceeded and pressures were increasing. Some other bearing material had to be found which would function under these new conditions.

High-lead bronzes which had been used as solid bearings under all sorts of conditions for many years were found to answer the temperature and pressure requirements, but the copper-lead mixtures when stiffened by the use of tin produced too hard a bearing. To use a solid bearing composed mainly of copper and lead alone, was too much like going back to the former solid die cast babbitt bearing. In the conventional copper-lead bearing, the difficulty was to line the steel back with a copper-lead mixture. To consistently manufacture a good bearing of this type was not an easy task and the cost of production was high. However, this material successfully met the demands imposed on bearings by the radial aircraft engine.

During this time conditions in the automotive field also were changing. Speed, acceleration, bearing pressures and temperatures were increasing, and before long another field of usefulness for the copper-lead bearing was apparent. Numerous improvements have been made recently in this bearing for automobile use, and now, thin-walled bearings of this type are offered as one of the new advances in bearing manufacture.

While the endeavor was being made to adapt copper-lead to new conditions, a number of researches were

conducted for the purpose of discovering entirely new bearing alloys to fill requirements which the tin-base babbitt no longer met. Success was found in changing from tin to cadmium as a base. Two such alloys, cadmium-nickel and cadmium-silver, are considered among the advanced bearing materials employed in the modern motor car.

The cadmium alloys hardened with from one to three per cent of nickel are especially interesting in that they can be directly bonded to the steel back of the bearing in exactly the same manner as the older tin-base babbitts. This bond, which is of extreme importance in all bearings, has an advantage in the cadmium-nickel alloy even over the tin babbitt in that no brittle compound is formed at the junction of the bearing metal and the steel backing.

Cadmium-nickel alloys combine lower coefficients of friction than the conventional babbitts with greater toughness and strength. In appearance they resemble babbitt and in manufacture are handled in much the same way.

While the hardness of the cadmium-nickel alloy is greater than that of babbitt, the hard constituent of the alloy is not too hard for even the softest steel shaft ordinarily used. The compressive strength is likewise considerably greater, and the cadmium-nickel alloy retains a greater percentage of its initial hardness and compressive strength at elevated temperatures.

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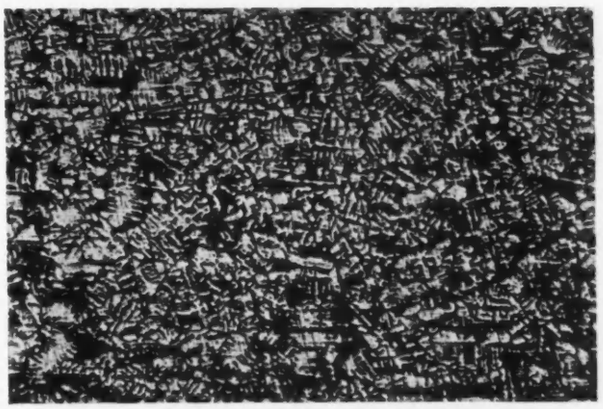


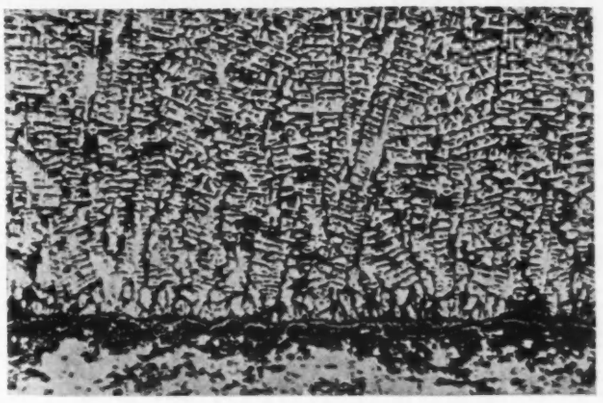


Fig. 1 (Above)—Microstructure at 50 diameters of the surface of a copper-lead bearing showing copper crystals in a lead matrix. Fig. 2 (Below)—Cross-section at 50 diameters through the wall of a steel-backed copper-lead bearing

Copper-Lead Bearings

D. E. ANDERSON
Chief Engineer, Bohn Aluminum and Brass Corporation

INHERENT advantages of copper-lead bearings for heavy duty service were recognized a number of years ago. Their adaptation to use in passenger car, truck and bus engines has been a rather long and tedious process of developing a metallurgical and production technique that would insure consistent quality, and a reasonable cost in large scale quantities.

Only about 0.3 per cent of lead is soluble in copper at room temperatures. Since the lead content of an average copper-lead bearing material is usually about 30 per cent, nearly all the lead in such a bearing is unalloyed with copper. The freezing point of copper is close to 2,000 deg. F., while that of lead is around 600 deg. F. Obviously, the copper will completely solidify on cooling while the lead is still in liquid form. With this difference in melting point the copper tends to segregate from the lead, giving a bearing which has either lead on top and copper below, or vice versa.

In bonding copper-lead bearings to a steel shell the copper itself has to alloy with the steel backing to form the bond. In a babbitt-lined bearing the surface of the backing material can be tinned at relatively low temperatures, but in the copper-lead bearing the steel backing must be brought to a high temperature to bond with copper. Since steel at such temperatures oxidizes readily, the steel backing must be heated in a neutral atmosphere to obtain a good bond and special fluxes must be used to prevent scaling.

Internal or grain structure of the copper-lead material largely determines whether or not the bearing will be satisfactory in use. In the copper-lead material the lead serves mainly as a "lubricant" retained in finely dispersed form by the harder copper that carries the bearing load, as shown in Fig. 1. Therefore, the copper crystals must extend from the surface to the backing of the bearing, as in Fig. 2, which shows a vertical section through the bearing.

For satisfactory performance as a bearing the copper-lead material must meet five requirements:

1. The copper crystals on cooling must arrange themselves vertical to the backing material.
2. The copper particles must be as fine as possible in order to disperse the lead in the bearing material.
3. To obtain a good bond with the steel more than the average percentage of copper must solidify at the bond.
4. To insure good bearing properties there should be somewhat more than the average percentage of lead at the surface of the bearing.
5. To prevent excessive localized wear no large amounts of segregated lead must appear near the sur-

face. The copper must not only carry the load, but also retain the lead in the bearing material.

To meet these requirements a special method of pouring and a specialized cooling technique had to be developed. With this process the proper distribution of lead and copper is obtained when the bearing cools from the casting temperature.

Once such a bearing has been produced it will stand much higher compressive loads than babbitt, since the strong copper crystals extending from surface to backing prevent displacement of the material under load.

▼ ▼ ▼

Cadmium-Silver-Copper Bearing Alloy

L. C. BLOMSTROM
Chief Engineer, Federal-Mogul Corporation

TO MEET the requirements for a material with a higher melting point and greater fatigue resisting qualities than tin-base babbitt, the Federal-Mogul Corporation undertook an extensive research to develop a new bearing alloy. Because of its physical characteristics, cadmium was selected as the most promising of the elements for bearing metal purposes. With a melting point well above that of tin, cadmium alloys were found to retain considerable strength at temperatures beyond the reach of the tin-base alloys.

Relatively small additions of silver greatly improved casting qualities of cadmium by making it less susceptible to oxidation at casting temperatures. The silver content also improved the fluidity, and had a marked influence upon the structural and physical characteristics of cadmium. There is a definite increase in hardness with an increase in silver content, but the addition of the third element, copper, permitted a reduction in silver content without reducing the hardness.

The microstructure of this alloy is shown in Fig. 1. The alloy has a melting point 133 deg. F. higher than the tin-base babbitts, as shown in Table I, and has higher physical properties at all operating temperatures.

The cadmium-silver-copper alloy, although harder than the tin-base babbitts, will not score the average automotive crankshaft of relatively low hardness.

Fig. 1—Microstructure of the cadmium-silver-copper alloy at 200 diameters

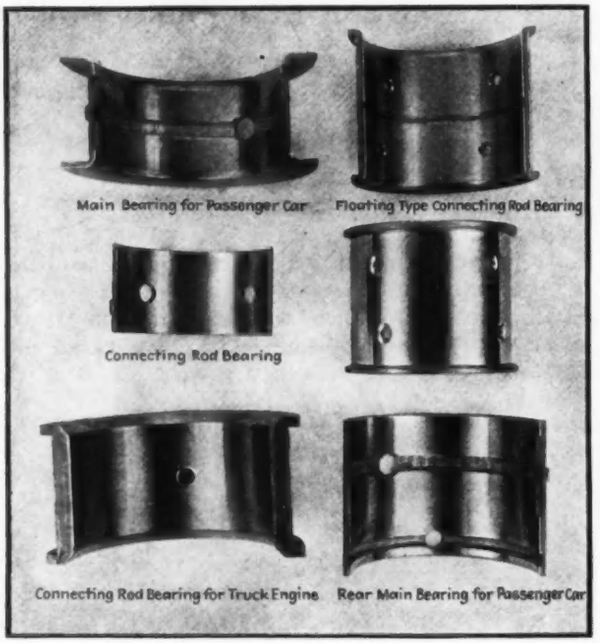

Main Bearing for Passenger Car
Floating Type Connecting Rod Bearing
Connecting Rod Bearing
Connecting Rod Bearing for Truck Engine
Rear Main Bearing for Passenger Car

Fig. 2—Typical main and connecting-rod bearings faced with cadmium-silver-copper bearing metal

TABLE I—Temperature Characteristics Cadmium-Silver-Copper Alloy and Babbitt

	Cadmium-Silver Copper Alloy	S.A.E. 11 Babbitt
Melting point, deg. F	598	465
Tensile strength, lb. per sq.in.		
Room temperature	18,000	12,500
400 deg. F	4,350	1,500
Elongation, per cent		
Room temperature	50	4.5
400 deg. F	68	85
Brinell hardness		
Room temperature	40	25
400 deg. F	8	4.5

Tests in engines operating at 3,500 r.p.m. for 200 hours show normal conditions of wear on the journal surface. The new cadmium base alloy, however, offers greater resistance to "cracking" of the lining as compared with tin-base babbitts under similar conditions.

Friction tests indicate that this alloy has a coefficient of friction lower than that of either the tin-base babbitts or the copper-base alloys. Tests in a special bearing testing machine show that the cadmium alloy will withstand higher loads than the tin-base babbitts. Speeds as high as 4,500 r.p.m. have been obtained on this machine, with running clearances no greater than those commonly used with the usual babbitts.

The production of steel-backed bearings with the cadmium-silver-copper lining presents no unusual manufacturing difficulties. The alloy can be poured or cast centrifugally in the shells in much the same way as when using tin-base babbitts. The alloy machines easily and does not necessitate any changes in the present process of machining lined bearings.

Outstanding applications for this new alloy are for

crankshaft bearings in automotive engines, including main journal bearings as well as the crankpin or connecting rod bearings, such as those shown in Fig. 2. In the floating type bearing requiring bearing metal on both the outside and the inside of the steel conventional tin-base alloys did not show sufficient bearing life. The cadmium-base alloy has satisfactory bearing life, and in comparison with copper-lead lined shells, offers greater protection against scoring of the journals.

Although the cadmium alloys are susceptible to corrosion from certain types of lubricating oils, they are affected far less than other new bearing alloys. But it is recommended that only high grade mineral oils, or oils which have been approved by the oil producer or by the engine manufacturer be used.

▼ ▼ ▼

Cadmium-Nickel Bearing Alloys

A. J. PHILLIPS
American Smelting & Refining Company

BEARING alloys of the cadmium-nickel type have for their essential base pure cadmium alloyed with 1.3 per cent nickel. The alloy is modified by the addition of such materials as copper, magnesium, silver, and even zinc. These alloying additions are used to stiffen the metal, and do not modify the alloy structure. In general, the stiffening additions are unnecessary.

Microscopically, the metal resembles to a marked degree an ordinary tin-base bearing alloy. The cross section has about 15 to 20 per cent by volume of a hard cadmium-nickel compound in a matrix of relatively soft cadmium-nickel eutectic. Because of this duplex structure the bearing alloy as a whole is quite soft, probably the softest of all the cadmium bearing alloys. This permits the alloy to seat itself properly as a bearing and to show high resistance to shattering under impact. The hard particles which act as a bearing surface permit the metal to support high loads with little wear.

Resistance to wear cannot be attributed directly to the alloy but rather to the fact that the structure of the alloy permits the lubricating oil to function properly. It is probable that the duplex type of bearing structure permits a partial oil film to be retained between the bearing and shaft even upon long standing. This is explained by the fact that the hard particles of the bearing metal in relief prevent complete metal to metal contact.

Tests have shown that the 1.3 per cent nickel material has a coefficient of friction slightly less than that of the SAE 12 babbitt. Another advantage of the cadmium-nickel alloy lies in the fact that it bonds readily to the ordinary steels used for bearing backs. The bond is somewhat analogous to a weld since the alloy does not form intermetallic compounds with steel but wets the metal, possibly because of a slight penetrating action by the nickel. This bond is usually as strong or stronger than the bearing alloy itself.

Fatigue strength of the cadmium-nickel alloy containing 1.3 per cent nickel is about 3,800 lb. per sq. in. (20,000,000 reversals) while that for the ordinary tin babbitts is between 2,000 and 2,500 lb. per sq.in. But, as shown in Fig. 1, the most important property of the cadmium-nickel bearing is its high melting point, giving the cadmium alloys much greater strength at elevated temperatures.

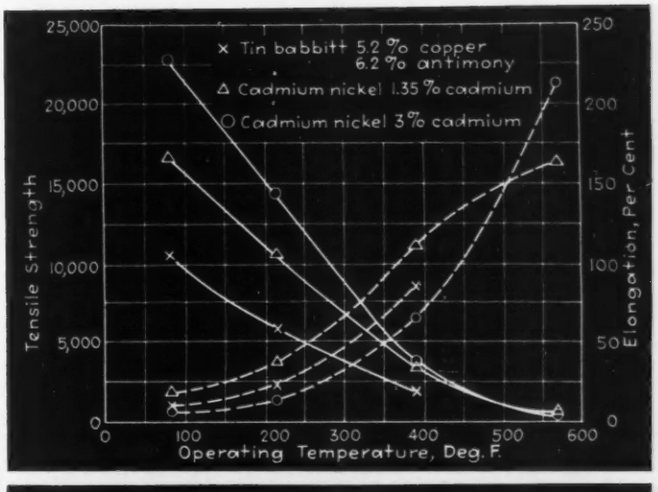
Initial softening of the cadmium nickel alloy takes place at 604 deg. F. while the tin-base babbitt is molten at 475 deg. F. This property is of advantage in bearings for the automotive field, such as shown in Fig. 2, where operating temperatures are increasing to a point where a tin alloy would melt and run out of the bearing. On the other hand, the melting point of the alloy is not sufficiently high to make it difficult to produce good bearings cheaply.

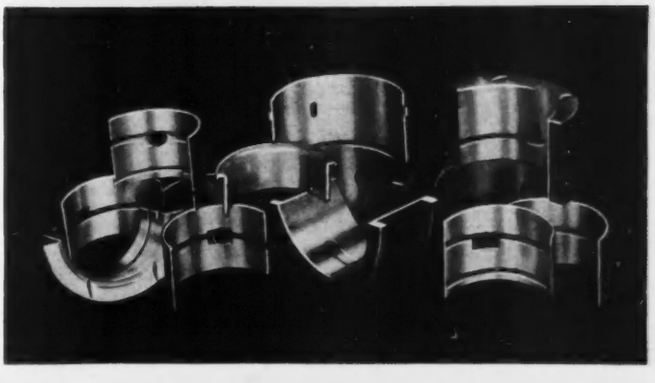
Cadmium-nickel bearings can be produced by modifying only slightly the equipment used for tin-babbitt bearings. In regular production the percentage of perfect bearings produced is at least as high and possibly higher than that obtained in the production of regular tin-babbitts.

Cadmium-nickel bearings have now been in active service for more than three years under most difficult conditions. The alloy has been applied commercially to automobile bearings for more than two years, and it now seems certain that the cadmium-nickel bearing has won for itself a field of use where heavy loads and high temperatures prohibit the use of regular tin-babbitt.

Contributions describing lead-alkali, nickel bronze, graphited and other types of recently developed bearing materials will appear in the December number.

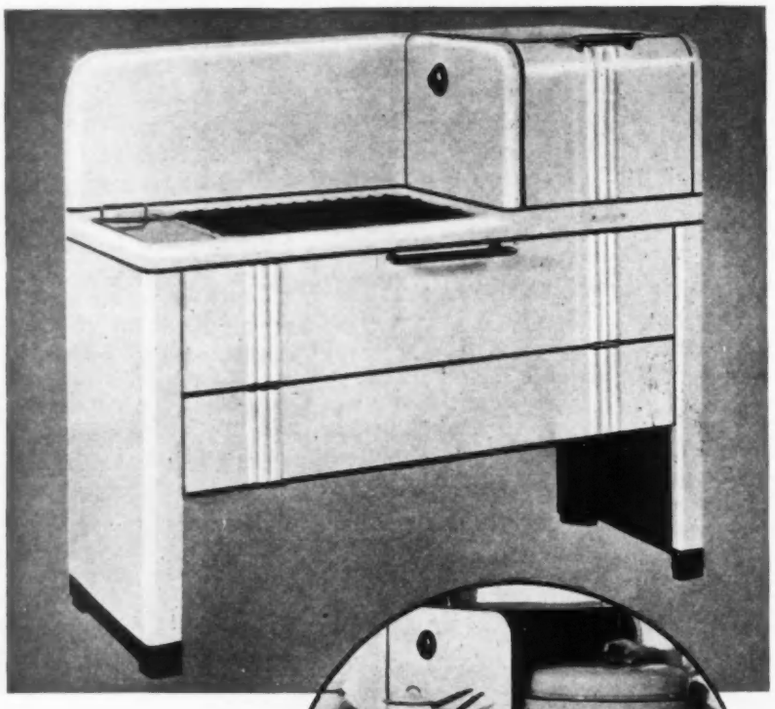
Fig. 1 (Above)—At elevated temperatures, the cadmium-base alloys have higher strength than tin babbitt. Fig. 2 (Below)—Cadmium-nickel bearings used for both connecting rod and main crankshaft bearings in one low-priced car

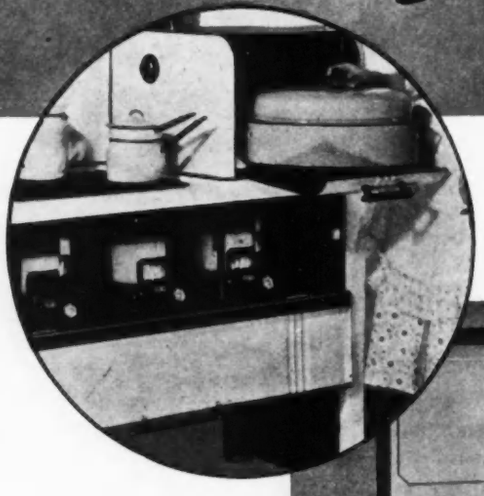




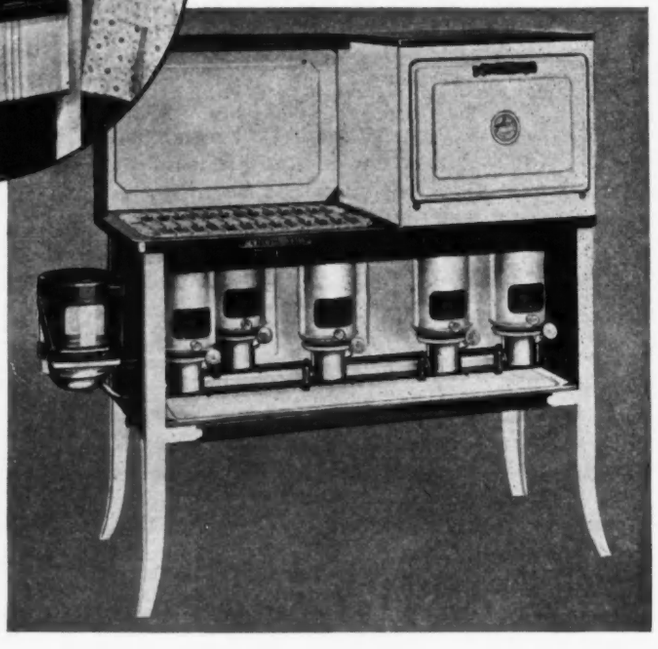
PRODUCT DEVELOPMENTS

Less Detail Improves Appearance





Rounded corners, smooth surfaces and less detail transformed the old model Perfection oil stove into a sturdy, easily cleaned, convenient range for a rural market. Accessibility to the oven interior (circle) is improved by extending the door into the top surface



● In the new Perfection oil range designed by Wilbur Henry Adams, modern beauty and styling is brought to a level equal to the appearance of electric and gas ranges. Starting with the former model shown to the right, the design problem was just how far simplicity could be carried in an oil range designed primarily for a rural market. Electric and gas ranges have been designed to meet modern demands of city people, but an analysis of the market proved that such designs would not be suitable for an oil range.

Shape, size and form selected for the new model follow the old model closely, while improvement in design was obtained by the use of rounded corners, smooth, flat surfaces, and the elimination of detail. The burners are inclosed and hid from view by a long hinged access door. In the two sheet metal sections making up the front, vertical beads matching the hinges are used for a decorative effect. Chrome and black plastic handles add contrast to the white porcelain enamel finish.

In cleaning up detail, one of the greatest improvements was obtained by building in the fuel tank. Raising a lift-up door at the left of the burners brings the container out and clear of the stove for easy refilling. Further improvement in strength as well as appearance resulted from carrying the end panels to the floor. Four adjustable metal pads under corners can be adjusted to allow for uneven floors.

Both the oven and the access door handles were designed for greater convenience. The oven door is carried up around the front curve making the handle not only more accessible, but giving a better view of the inside of the oven and greater

accessibility to the interior when the door is open. When the access door is opened the handle, mounted on hinges, swings clear of the door.

• *Designing for 25,000 R.P.M.*

In the design of the new Hand-ee grinder shown in Fig. 1, made by the Chicago Wheel & Manufacturing Company, it was necessary to eliminate friction losses as far as possible in order to reduce the size and weight of the motor. High-speed precision ball bearings used are fully protected and filled with sufficient lubricant to last the life of the bearings. The motor operates at an idle speed of 25,000 r.p.m. requiring the armature to be statically and dynamically balanced to close limits.

In such small motors, frictional loss at the commutator is relatively large and directly influences the size of the motor. A radial type of commutator instead of the usual cylindrical type was developed for this design, resulting in lower centrifugal forces as well as reduced friction. All of the copper conducting parts of the commutator are stamped in a single piece, and bakelite is molded as an insert into the stamping. As shown in Fig. 2, the portions of the stampings which form segments are tied together with a ridge which is turned off after the molding operation is completed. When this ridge is removed, the commutator segments are electrically insulated and held in place by the molded plastic.

The high operating speed of 25,000 r.p.m. requires extremely accurate limits in manufacture and balancing. In balancing the rotor, so little material is available for removal that the balancing is performed by grinding off part of the armature lamination.

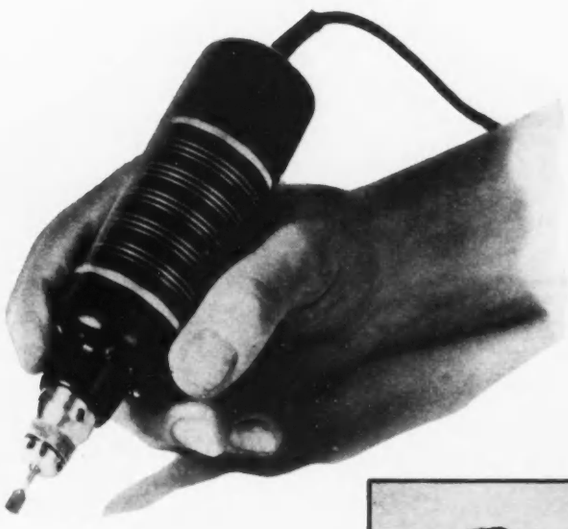


Fig. 1—Sealed ball bearings, and a radial commutator reduce friction in the Hand-ee grinder, making possible the small motor size. With a bakelite case, the grinder weighs but 10 ounces

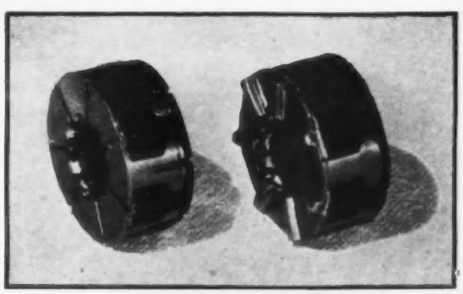
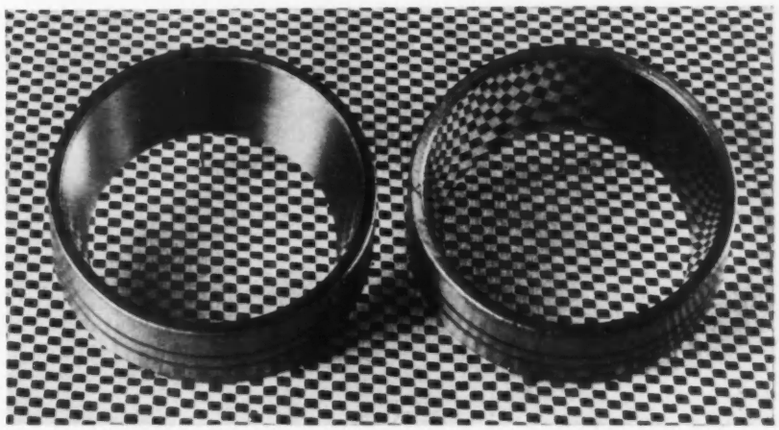


Fig. 2—After the plastic is molded into the copper stamping, the ridges are turned off, electrically separating the segments



Comparison of standard ground finish (left) with the new mirror finish (right) now being applied to Timken bearings

• *Mirror Finish on Timken Bearings*

Long life, quiet operation, minimum internal friction, and increased efficiency of lubrication are some of the advantages expected from a mirror finish now being applied to the races of many Timken bearings.

This improved finish was made possible by the use of the Profilograph, an instrument designed by Dr. E. J. Abbott of the University of Michigan. By a combination of mechanical and optical levers, surface irregularities in a test piece can be magnified so that surface finish can be measured quantitatively with a high degree of accuracy.

With this accurate means of measuring surface finish, combinations of grits, wheels, speeds and feeds were obtained which, with special grinding coolants, result in a finish much smoother than a ground surface.

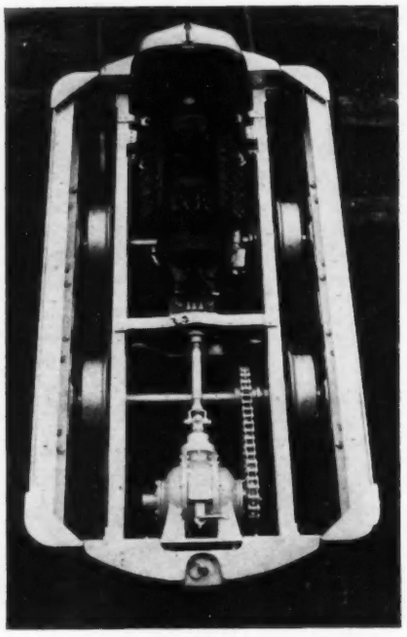
• *Welded Bicycle Frames*

Now that the bicycle is coming back, lessons learned from the automobile industry in reducing cost, improving appearance and eliminating weight are being applied by the bicycle manufacturers. In many of the new models, expensive castings have been discarded in favor of resistance-welded assemblies, and riveting and brazing operations are being replaced by flash welding.

Flash-welded joints are being used for front forks, frames, head assemblies, and back stay bridges at the rear axle. In one design the chain stay end of the bridge assem-

bly is a low cost stamping with projections embossed on both sides. The stamping is inserted inside the flattened tubular members and projection welded.

In a design making use of Thomson-Gibb welding machines, boys and girls bicycles are assembled from parts that are identical except for the head assembly. Even this part is the same for both types except for the position of the tee on the vertical tube.



Power is supplied by a standard Ford V-8 truck engine and transmission driving all four wheels through a chain drive

• *Bolted Frames for Industrial Locomotives*

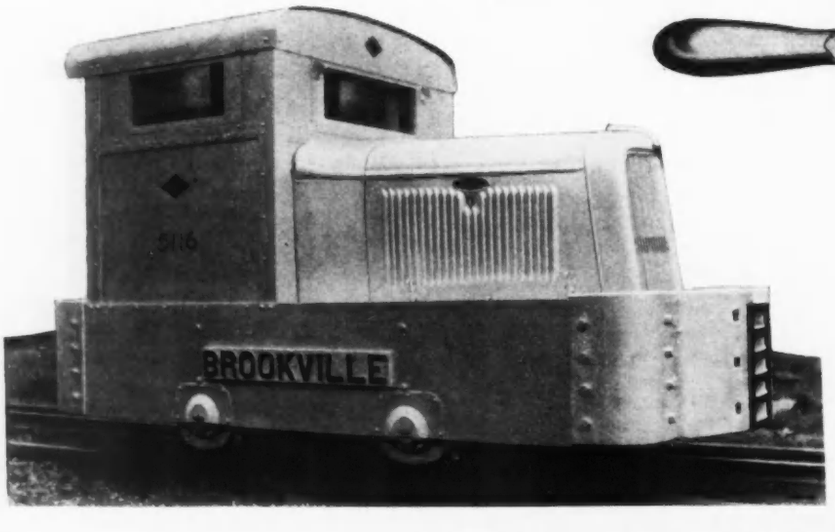
In the new Brookville Locomotive, the steel frame is bolted together using cast steel end sills and structural steel longitudinal sections and braces. Although a welded frame of the same strength would weigh 25 per cent less than the bolted structure, this weight would have to be added in some other part of the locomotive in order to obtain traction. By placing the weight in the frame, the weight is better distributed.

Since the locomotive must be designed for track gages from 18 to 56½ in., the design of the frame cannot be standardized as a unit. With the bolted construction, however, the frame for any track gage can be assembled from standard longitudinal members made from rolled steel sections with special end sills corresponding to the track gage. The construction also gives greater flexibility than is obtainable from welded construction. In holding locomotives to the rails over rough and uneven tracks this flexibility is desirable.

Industrial locomotives are also subject to severe abuse such as wrecks, derailment and collisions. Repairs can be made to damaged sections of the bolted frame at lower costs than would be involved in repairing a welded frame.

Power for the locomotive is supplied by a standard Ford V-8 engine, with the standard clutch and 4-speed transmission used for truck service. To reduce friction all journal boxes are equipped with Timken bearings. As shown in the view of the chassis, all four wheels are driven from the reversing gear by a chain drive, using oversized roller chains.

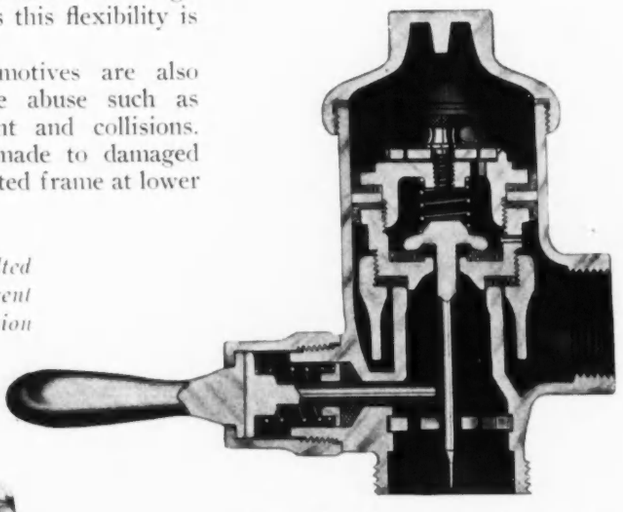
As compared with welded construction, the bolted frame for the Brookville locomotive is 25 per cent heavier, but the added weight gives better traction



• *Plastic Parts for Corrosion Resistance*

Flushing valves for marine service present a difficult corrosion problem. Parts of the valve are continuously submerged in sea water, and any change in the size and shape of vents and passages in the valve mechanism affect its operation. To avoid electrolytic action, metal parts in contact must be of similar composition.

In the new Wilson valve, bakelite is used for the piston which contains passages and ports controlling the variable rate of flow. By-passes are arranged so that the direction of flow reverses during the operation, keeping the holes washed clear and free from sediment. Dimensional changes do not affect the operation



Stainless steel operating pins and molded plastic parts for the piston in Wilson valves resist corrosion and insulate parts from electrolytic action encountered in marine service

of the piston since it is centered within the cylinder by double cup leather packings that permit large clearances.

In addition to the piston, the tilt valve and push pin are also of molded plastic. Valve seats in the form of flat circular disks are made of rubber and are held in place in the molded piston with bronze snap rings.

Although a plastic material would be desirable for the valve housing, this part is in contact with water only on the inside. Expansion resulting from water absorption, therefore, is not uniform. In attempts to use a molded plastic housing, stresses introduced by differential expansion caused the molded housing to warp and crack. The piston, however, is completely submerged and expands uniformly without warping.

• *Random Jottings*

Coil springs in the New Haven "Comet" in the trucks are made of silicon vanadium steel because of its high endurance, toughness and tensile strength. In new high-speed steam locomotives, built for the Baltimore & Ohio Railroad, normalized vanadium steel connecting rods are used to reduce reciprocating weight. This material has a tensile strength of 97,000 lb. per sq.in. with a reduction of area of 53 per cent.

Molybdenum steel developed by Chrysler for springs is now being used for rear axle drive shafts and its application to connecting rods is being developed. The composition in per cent is: Carbon, 0.58 to 0.68; manganese, 0.65 to 0.95; silicon, 0.20 to 0.30; molybdenum, 0.15 to 0.25.

Constant, uniform pressure essential for a tight, uniform wrapping in rubber hose is obtained by means of compressed air in a machine recently developed by the Farrel-Birmingham Company. The air is used to lower the rolls as well as to apply pressure, and raises the rolls when the operation is completed. Counterweights previously used have been eliminated. Automatic electro-pneumatic control of the roll operating mechanism is inter-connected with the driving motor and actuated by a foot treadle bar extending the entire length of the machine.

Human errors in weighing and recording fish in a sardine factory are eliminated in a Toledo scale weighing device having a capacity of 90 tons of fish an hour. Sardines are fed from a hopper onto the scale, the flow being stopped automatically by a photo-electric device on the scale when 750 lb. is reached. The scale then automatically prints the exact weight and the hopper is discharged. To resist attack from salt air and spray all exposed parts are cadmium plated; stainless steel pivots and bearings are used in the scale mechanism and lever and dial housing are sealed air-tight.

Rasping rattles in the old telegraph call box are silenced in the new design. New molded plastic case and base are smaller, handle is larger and colored red

Todd checkwriters are now available motorized, giving them an output of 1,500 checks an hour. After the amount is set up on the keyboard, an operating key is punched and the motor drives a sheet into the proper position under the checkwriter and prints the check. As the check is discharged a second sheet is moved into position for the next amount.

One manufacturer of molding machines seems to have achieved perfection, for he states "this machine is scientifically designed for the highest practical efficiency and includes the best possible material for each part. It is made by skilled mechanics and a strictly interchangeable manufacturing basis is adhered to."

The orange packing plant of the Fillmore Citrus Association at Fillmore, Calif., has walls and ceilings of mustard green-yellow and machinery and sorting tables in various shades of violet. These colors were specified by a color technician who studied the work to be done, and advised that they be used because they are complimentary to the orange color of the fruit and will relieve strain and fatigue in handling it, increasing the efficiency of the operators.

In sealing electric lamps to bases a small stream of molten glass is supplied by a glass furnace. Refractory dies formerly used in the orifice of the furnace would erode within a few hours, making it necessary to adjust the temperature in the glass furnace or change the composition of the glass itself to obtain a uniform stream. After numerous tests with high-temperature alloys and various refractory compositions, an alloy of 90 per cent platinum and 10 per cent rhodium was found to resist the abrasive action of the hot flowing glass. A lining of this alloy, 0.030 in. thick, is inserted into an Alundum refractory support to form the die.

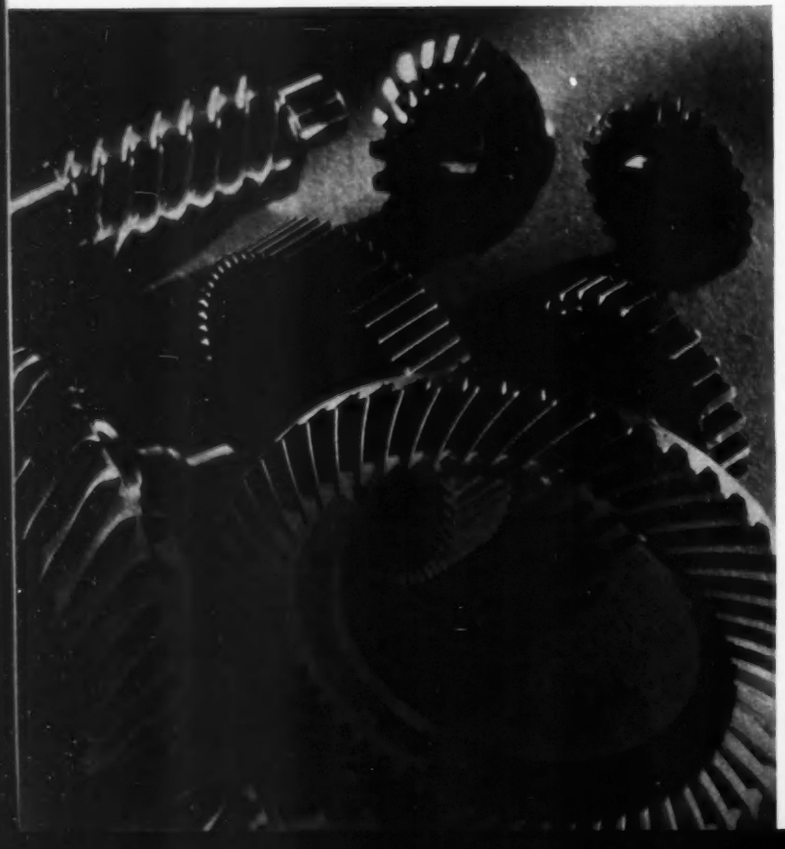
One machinery manufacturer has designed and built his machine of castings, but the design of these castings is such that the finished product has very much the appearance of welded construction. In view of the fact that a change to welded construction is contemplated in the future, the castings were designed so that the change in method of construction can be made at a later date if it is found desirable, without radically altering the appearance of the machine.

Nickel-Alloy Gear Materials and Their Heat-Treatments

J. W. SANDS and F. J. WALLS
Development and Research Department
The International Nickel Company, Inc.

By the addition of nickel to cast iron, steel or bronze, the material is better able to resist the complex strains, stresses and shocks inherent in gear drives

SELECTION of suitable gear materials has always been a complex problem because of the severe service conditions under which these parts must operate. They must be hard enough to resist a peculiar type of rolling and sliding friction, strong enough to guard against the stresses imposed, and tough enough to withstand the shocks and pulsations which are frequently encountered. The question is further complicated by the necessarily irregular shape which introduces stress concentration factors, often impossible to estimate. Thus, while it is frequently possible to effect decided improvements through judicious changes of design relative to more accurate bearings, increased stiffness and more uniform load distribution along the teeth, yet the modern trend toward increased speed and power, together with the requirements of greater reliability and longer life, dictate the use of higher grade materials. The addition of nickel, either alone or in combination with other elements, is frequently effective whether the base be steel, cast iron or bronze.



Gears Made of Steel

Nickel alloy steel gears in both the cast and forged types, are widely used in the automotive, aircraft, tractor, bus and marine fields, in machine tools, excavating and agricultural machinery, and in the railroad, mining and other industries employing high speed or heavy duty machinery. Except for certain large gears, such as turbine gears, which are often used in the normalized condition, forged gears are usually made of either the direct oil-hardening or of the case-hardening type steel, depending partly on the service and partly on personal preference. Direct-hardened gears are less expensive, because of the simplified heat-treatment and possess a higher tooth strength but have lower unit resistance to pitting and less resistance to shock than case-hardened gears.

The most commonly used direct-hardening

Table I—Direct Hardening Nickel-Alloy Gear Steels

S. A. E. No.	2350	3150	3250	3450	4345	4640
Carbon	0.50	0.50	0.50	0.50	0.45	0.40
Nickel	3.50	1.25	1.75	3.00	1.75	1.80
Chromium	——	0.60	1.10	0.75	0.75	——
Molybdenum	——	——	——	——	0.20	0.25
Quench Temp. deg. F.	1,425	1,450	1,450	1,425	1,500	1,500
Tensile Strength in thousand lb. per sq. in.	270	250	270	265	285	265
Yield Point, in thousand lb. per sq. in.	238	228	230	240	245	230
Elongation, per cent	9	7	8	11	11	10
Reduct. Area, per cent	33	25	32	42	35	37
Gear Size	M	S	M & L	L	L	M
Service	H	O	H	H	H	O

S = small L = large H = heavy duty
M = medium O = moderate service

gear-steels of nickel-alloy are listed in Table I. Some of these steels, notably S.A.E. 4640 and 3150, are especially well suited for cyaniding to provide skins of high hardness and improved wear resistance. All the steels are ordinarily oil quenched and tempered at 400 to 500 deg. F., with Brinell hardness values of 514 to 578. These steels are relatively insensitive to overheating, and as they are hardened in a mild coolant from relatively low temperatures, excessive distortion and scaling are avoided.

Of the steels in Table I, for the best combination of strength and toughness, S.A.E. 2450 is recommended for applications requiring a high quality gear of small or medium section as in automobile, bus and tractor transmission gears. S.A.E. 3150 is valuable when a definite improvement over carbon steel is required at low cost, as in machine-tool gears of moderate section. S.A.E. 3250 and 3450 should be specified when the section is such that a higher degree of depth hardening is required as for gears of heavy section, or for moderate-sized gears requiring better properties than those obtained with S.A.E. 3150. S.A.E. 3450 is particularly adapted to gears for high grade machine tools.

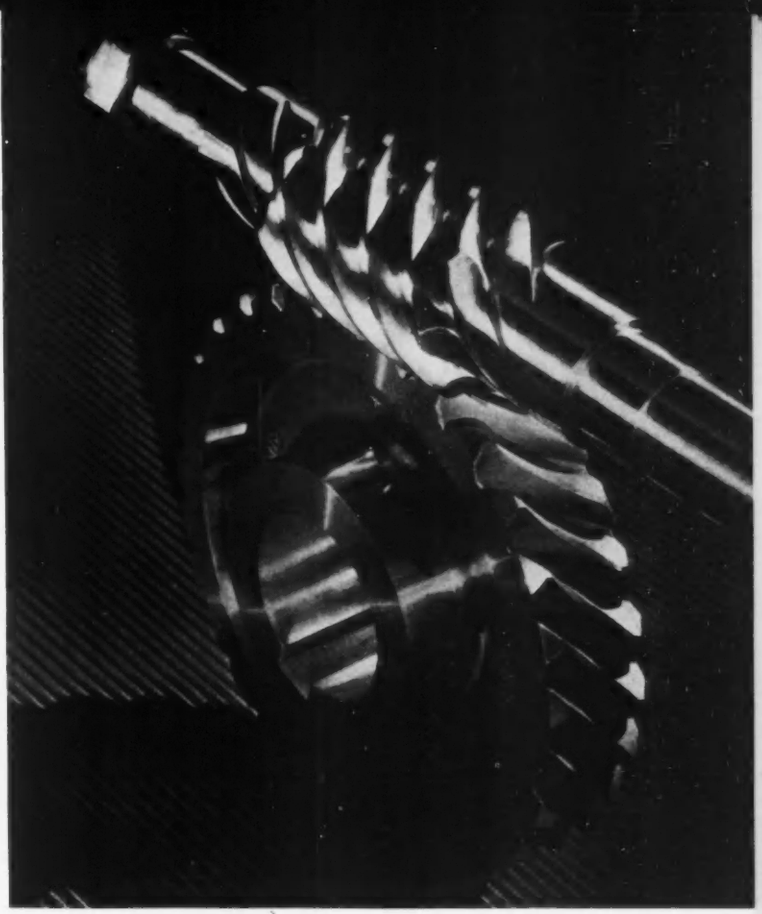
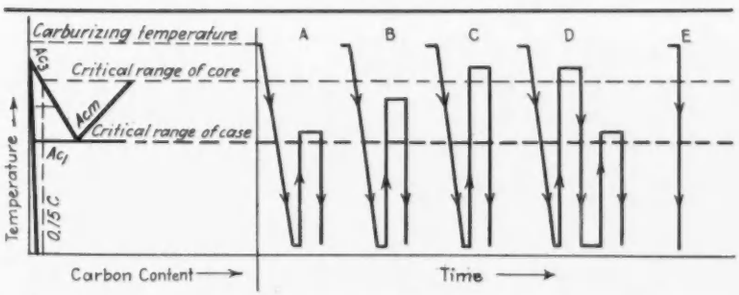


Table II—Case-Hardening Nickel-Alloy Gear-Steels

S.A.E. No.	2315	2515	3115	4615	4815	Krupp
Carbon	0.15	0.15	0.15	0.15	0.15	0.12
Nickel	3.50	5.00	1.25	1.80	3.50	4.10
Chromium	—	—	.60	—	—	1.40
Molybdenum	—	—	—	0.25	0.25	—
Size	M	M. & L	M	M	M & L	M & L
Service	H	H	O	O	H	H

M = medium L = large H = heavy duty O = moderate service

Table III—Different Treatments Subsequent to Carburization and the Case and Core Characteristics Obtained



Treatment	Case	Core
A (Best adapted to fine grained steels)	Refined; excess carbide not dissolved.	Unrefined; soft and machinable
B (Best adapted to fine-grained steels)	Slightly coarsened; some solution of excess carbide	Partially refined; stronger and tougher than (A)
C (Best adapted to fine-grai. ed steels)	Somewhat coarsened; solution of excess carbide favored; austenite retention promoted in highly alloyed steels	Refined; maximum core strength and hardness. Better combination of strength and ductility than (B)
D (Best treatment for coarse-grained steels)	Refined; solution of excess carbide favored; austenite retention minimized	Refined; soft and machinable; maximum toughness and resistance to impact
E (Adapted to fine-grained steels only)	Unrefined with excess carbide dissolved; austenite retained; distortion minimized; file proof when carbon is high	Unrefined but hardened

S.A.E. 4345 steel has excellent depth-hardening properties, but is somewhat difficult to handle in preliminary operations and during heat-treatment because of its air hardening tendencies. S.A.E. 4640 is steadily becoming popular because of its good combination of strength and toughness and excellent machining characteristics. Unless the gear is cyanide treated to impart added surface hardness it is customary to increase the carbon content to approximately 0.50 per cent.

Nickel alloy carburizing steels, used extensively for gears, combine dependability, uniformity, low-hardening temperatures and response to mild quenching. Such qualities show a reduction in warping, scaling, distortion and internal stress, resistance to grain growth and embrittlement, and superior mechanical properties of both case and core. The steels shown in Table II are most generally used.

Heat-treatments vary, as shown in Table III, according to the characteristics desired of the steel and the type of service. The left-hand portion of the chart is the usual iron-carbon equilibrium diagram from which are determined the quenching temperatures necessary to refine the case and core. These critical temperatures are also affected appreciably by the alloy content.

In the right-hand portion of the diagram in Table III a slanting downward line represents a slow cool, while a perpendicular

Table IV—Approximate Core Properties of Case Hardened Carbon and Nickel Alloy Steels

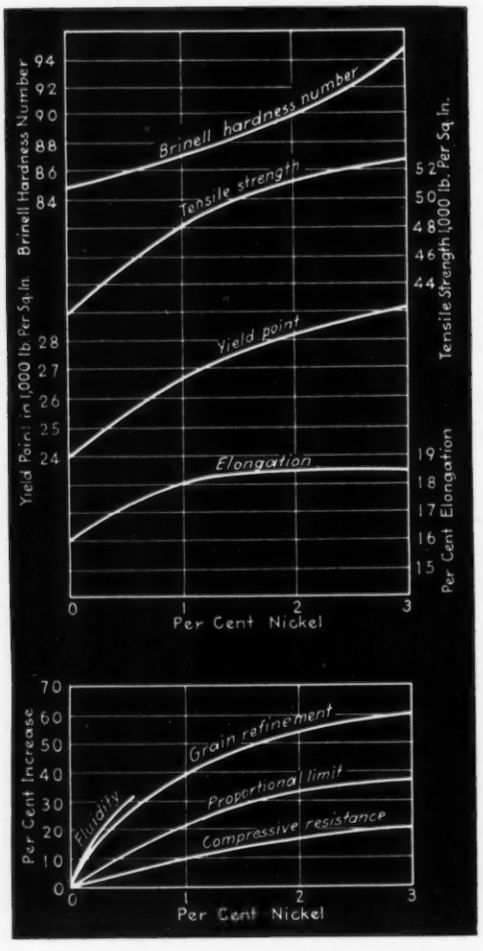
S.A.E. Steel No.	Approx. Crit. Range, Deg. F. of		Treatment after Carburizing			Core Properties					
	Core	Case	Type (Table III)	Heat, Deg. F.	Quench, in.	Yield Point, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elong. in 2 in. per cent	Red. Area, per cent	Brinell Hardness	Izod Impact ft. lb.
2315	1435	1305	A	1375	Oil	57,000	90,000	32	60	190	75
			A	1375	Water	60,000	95,000	28	55	200	60
			B	1425	Oil	85,000	115,000	21	51	225	55
			B	1425	Water	95,000	130,000	17	45	290	40
			C	1475	Oil	135,000	160,000	11	47	345	35
			C	1475	Water	150,000	180,000	9	45	390	30
			D	1525 Oil, 1375 Oil		60,000	95,000	35	65	195	85
			D	1525 Oil, 1375 Water		65,000	100,000	30	60	210	70
2515	1400	1285	A	1350	Oil	65,000	105,000	28	60	210	65
			A	1350	Water	70,000	115,000	26	55	230	50
			B	1400	Oil	110,000	140,000	18	55	260	45
			B	1400	Water	115,000	150,000	15	52	290	35
			C	1460	Oil	160,000	195,000	14	50	385	30
			C	1460	Water	165,000	200,000	13	50	390	30
			D	1500 Oil, 1350 Oil		70,000	110,000	30	65	220	75
			D	1500 Oil, 1350 Water		72,000	120,000	28	60	230	60
			D	1525 Oil, 1400 Oil		115,000	145,000	20	60	270	50
			D	1525 Oil, 1400 Water		120,000	155,000	17	55	295	40
3115	1460	1355	A-B	1400	Water	85,000	130,000	16	45	260	35
			A-B	1400	Oil	80,000	120,000	18	48	250	45
			C	1475	Water	155,000	180,000	10	30	360	25
			C	1475	Oil	125,000	155,000	13	43	335	30
			D	1550 Oil, 1400 Oil		85,000	125,000	25	55	255	55
4615	1515	1340	B	1425	Oil	70,000	105,000	25	55	200	60
			B	1425	Water	80,000	115,000	22	50	220	40
			C	1525	Oil	105,000	145,000	17	52	300	35
			C	1525	Water	110,000	150,000	17	50	300	30
			D	1550 Oil, 1425 Oil		75,000	110,000	28	57	215	75
			D	1550 Oil, 1425 Water		85,000	120,000	25	52	230	55
4815	1435	1305	C	1460	Oil	165,000	200,000	14	54	375	—
"Krupp steel"	1430	1320	A-B	1400	Oil	165,000	195,000	12	40	390	35
			D	1525 Oil, 1400 Oil		170,000	200,000	13	42	400	40

downward line represents a liquid quench. Treatment *B*, for example, is a box cool from the carburizing temperature, followed by a liquid quench after a reheating to a temperature somewhat below the critical range of the core. The core will thus be only partially refined, while the case will be completely refined, although slightly coarsened because the quenching temperature is considerably above the optimum for the case. Treatment *D* in this notation is a double quench designed to refine both the core and the case in turn. Treatment *E* is a direct quench from the carburizing box, and is suitable for S.A.E. 4615 steel.

In Table IV are shown suitable quenching temperatures for applying the various treatments to the steels under consideration as well as representative core properties resulting therefrom.

Of the steels shown in Tables II and IV, probably the ultimate in resistance to fatigue and wear is developed in the S.A.E. 2515, S.A.E. 4815 and "Krupp" steels. These steels are used for heavy truck and bus gears which are subject to continuous heavy duty and abuse and in aircraft where considerations of safety dictate the use of the very best materials. Where requirements are not so severe, S.A.E. 2315 steel serves admirably. S.A.E. 4615 is popular for automotive gears, because file hard cases from oil quenching with core strengths almost as high as those for S.A.E. 2315 can be ob-

In the charts below are shown the modification in properties of bronzes containing 11.1 per cent tin, 0.03 per cent phosphorus, nickel as indicated and the balance copper, a type frequently used for gears



tained. Frequently the higher carbon grade S.A.E. 4620 is used to secure an appreciable increase in core strength. S.A.E. 3115 is a low-cost steel of excellent properties widely used for differential gears, truck and tractor transmission gears and machine-tool gears. When made under carefully controlled conditions, excellent gear properties can be obtained at moderate cost. This steel also is often used in its higher carbon modification as S.A.E. 3120 steel.

Cast nickel alloy steels are used in all sizes from the smallest to the largest gears, the latter not being readily manufactured from wrought steel. Usually such gears are given a simple heat-treatment such as normalize

and draw, but frequently are hardened by liquid quenching when service conditions are severe. In Table V are given the chemical composition of cast gear steels.

Heat-Treated Cast-Iron Gears

Most cast-iron gears are finished from metal in the "as-cast" condition. In some instances the only heat-treatment used is one to relieve casting stresses and is usually accomplished by heating the gear slowly to about 1,000 deg. F., where it is held one hour for each inch of cross section and then allowed to cool slowly.

When heat-treatment is applicable, and improved wear with higher strengths are desired, gears of simple shape, section and contour can be oil quenched from 1,550-1,600 deg. F. and drawn to 700-1,000 deg. F. The tensile strength is usually increased by 20 to 30 per cent and the hardness approximately doubled, depending on drawing temperature and composition. Table VI shows the chemical and physical properties of alloy cast iron used for gears.

For special applications, such as pump gears used in handling corrosive liquids in the paper, petroleum and chemical industries, the austenitic cast iron, as shown in the last column of Table VI, has been adopted quite generally.

In justifying the use of a specific composition, it may be said generally that where gears are subjected to impact loading, the plain nickel and nickel-molybdenum high test type irons have proved most satisfactory and where constant loading and resistance to wear are primary factors, the nickel-chromium is best.

Bronze Alloy Gears

In the manufacture of bronze gears, small additions of nickel varying from ½ to 3 per cent have been found of value both for improving the mechanical properties and in reducing casting difficulties. Nickel acts as a combined strengthening and toughening agent frequently leading to an increase in ductility as well. Its effects on the casting properties are varied. Although nickel slightly increases the melting point and might be expected to diminish the ease of filling all parts of the mold, the reverse is actually so, with the result that casting temperatures may be appreciably lowered while at the same time increasing the fluidity of the metal. This effect is distinct in the presence of as little as 0.50 per cent of nickel. Nickel also imparts grain refinement, increased density and improved fracture.

Consequently many gear manufacturers have found it advisable to add 1 or 2 per cent of nickel to take advantage of the benefits thus obtainable. An indication of

Table V—Compositions for Cast Steel Gears

Steel	1	2	3	4	5	6	7
Carbon	0.25	0.35	0.35	0.35	0.42	0.30	0.42
Manganese	0.85	0.75	0.75	0.75	0.70	0.70	0.70
Nickel	2.00	1.50	1.50	1.75	1.50	2.00	2.50
Chromium	——	0.75	....	0.75	0.75	0.75	0.90
Molybdenum	——	——	0.25	0.30	——	0.20	——
Heat Treatment	N & D	N & D	N & D	N & D	Q & T	Q & T	Q & T
Section	L	S & M	S & M	M & L	S & M	S, M, L,	M & L
Service	A	O	O	B	B	B	B

N & D = normalized and drawn
Q & T = quenched and tempered
L = large M = medium S = small
A = gears not subject to severe abrasion
B = highly stressed gears
O = moderate service

Table VI—Composition and Physical Properties of Cast Iron Gears

Service	Small Gears	Small Machinery	Large Machinery	Diesel Engine	Heavy Duty	Corrosion
Nickel	1.00	1.25	2.00	1.50	2.00	14.00
Chromium	0.30	——	0.30	0.50	——	2.00
Molybdenum	——	——	——	0.60	0.65	——
Total carbon	3.40	3.30	3.00	3.00	3.00	2.90
Silicon	2.20	1.50	1.00	2.00	1.50	1.50
Manganese	0.70	0.55	0.80	0.70	0.80	1.00
Copper	——	——	——	——	——	6.00
Tensile strength in thousand lb. per sq. in	30	38	42	48	50	25
Brinell Hardness, as-cast	200	200	220	220	230	180

the magnitude of some of these effects on the commonly used 89-11 gear material is given in the accompanying curves.

The curves shown are for bronzes containing 11.1 per cent tin, 0.03 per cent phosphorus, nickel as indicated on the charts, and the balance copper. These cover types of bronzes frequently used in the manufacture of gears. A nickel content of 1.00 per cent increases the proportional limit more than 20 per cent and compressive resistance 10 per cent. Tensile strength, yield point and Brinell hardness are increased similarly. Beyond 1.00 per cent nickel, elongation remains about the same.

EDITOR'S NOTE—*Additional data on properties and applications of gear materials and their heat-treatment will appear in forthcoming numbers of Product Engineering.*

Resistance Welding And the Metal Vacuum Tube

R. J. BONDLEY
General Electric Company

METAL-ENVELOPE vacuum tubes have many desirable properties, such as ruggedness, compactness, ideal shielding, freedom from tube noise, and ease of fabrication. Also, a small size of tube is possible because metal has better heat conductivity than glass, and because the metal parts may be held to close tolerances. This reduction in size would not result in any sacrifice in performance as the internal parts could be full size.

But a practical metal-tube design suitable for high-speed production, such as those shown in Fig. 1, was not possible until two recent developments had been accomplished. First, it required an alloy with expansion characteristics substantially the same as those of glass, in order to make strain-free seals where the conducting leads entered the tube. Secondly, the metal tube had to await the development of high-speed control of resistance-welding apparatus, by means of Thyratron and other electron tubes, to make possible dependable welds at high-production speed.

Given a glass and metal with expansion coefficients which match, the engineer could readily design a suitable stem or header for a metal tube. Securing this header to the envelope or shell, however, required different equipment from that which the vacuum-tube and lamp industries use for sealing the stem to the bulbs. Arc, acetylene, and atomic-hydrogen welding, as well as various other forms of welding, brazing and soldering, are generally unsuitable for this purpose because of the resulting porosity of the joint, the damage to internal tube parts from the heat of welding, or inability of the process to be adapted to production requirements. Resistance welding was the only satisfactory method that could produce welds possessing the required characteristics, and the development of seam welders controlled by electronic tubes solved the problem.

Thyratron-tube control is used to limit the duration of current for each weld to a small fraction of a second and to assure consistency of welds. If the weld was made with a current flowing for as long as one-fourth of a second, the current would pass from one electrode to the other through the wall of the tube instead of through the joint to be welded. This would result in inconsistent welds and excessive heat and oxidation of the tube parts—a possibility obviated by accurate timing obtained from electronic control equipment.

In tubes greater than two inches in diameter, heads are seam-welded to the shells by conventional methods. However, on smaller tubes, such as those for radio receivers, seam welding becomes cumbersome because of the small size of welding mandrels required, difficulties in chucking and alignment, and the low volume of output attainable. This dictated a design of tube using a hollow spot or annular projection weld.

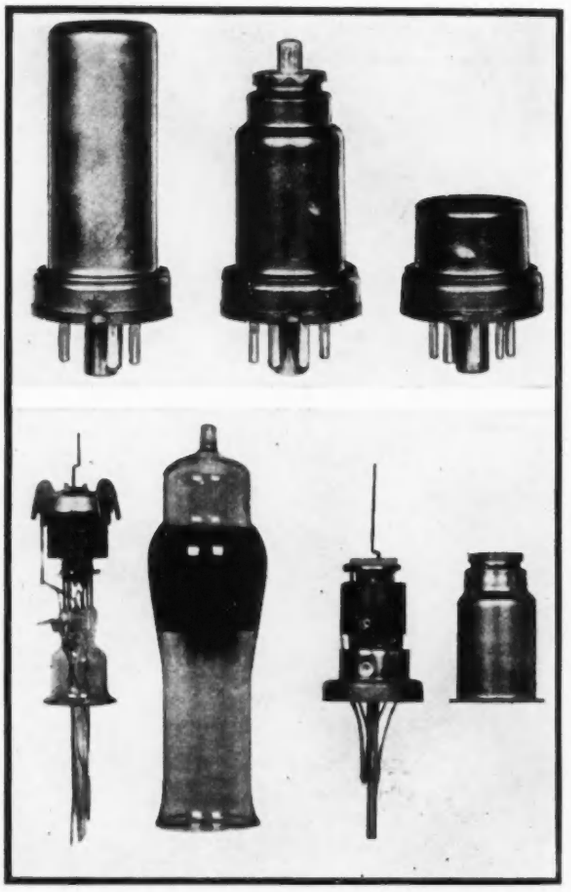


Fig. 1 (Above)—Metal vacuum tubes were not commercially possible until the high-speed control of resistance welding machines had been developed. Fig. 2 (Below)—Bulbs and mounts of two pentode radio tubes; to the left is shown the typical glass-type tube, and to the right its metal counterpart

In Fig. 2 are shown the bulbs and mounts of two pentode radio tubes—one a typical glass-type tube and the other its metal counterpart. In the glass construction, the metal structure supported by glass is mechanically weak. The stem "pinch" carries not only the leads which are connected to the tube elements, but also the studs used to give additional support for the tube structure. The metal-tube stem supports its mount

directly by rods welded to the inner surface of the bead; the seals contain only the lead connections to the various elements.

In the manufacture of the glass tube, the bulb is sealed to its stem by rotating the bulb and stem in a flame. Upon cooling, the glass shrinks onto the flange on the stem and thereby seals it, while the excess material below the flange is heated until it parts and drops away. The whole sealing-in process requires from one to two minutes. The tube is then evacuated through the glass tubing in the stem. After being exhausted, the tube is sealed off by heating the exhaust tubing until it collapses and fuses together.

In contrast, the metal container for the metal tube is welded to the header with a single application of current. A small embossing or ring is pressed or extruded near the periphery of the header where the weld is to be made. Fig. 3 is a cross-section of a shell and header placed in the electrode ready for welding. The header is centered by the locating nest.

When the upper electrode descends, the header is held against the flange on the shell with a definite resilient pressure. A current passing through the electrodes heats the embossed ring as well as the surface upon which it rests to a fusion temperature. Since the upper electrode is held down with either spring or pneumatic pressure, the instant the metals become plastic, they are forged together, completing the weld. Duration of the flow of current, accurately controlled by the electronic timer, is from 0.02 to 0.05 sec., depending upon the thickness of the material being welded. Only the projection is heated, the amount of heat being so small that the tubes can be immediately lifted from the electrodes and handled with bare hands.

Sealing-off the tubes after exhaust is a process unique to metal tubes. The exhaust tubing is flanged and welded to an embossing on the head or shell. After the tube is exhausted the stem is pinched flat and welded tight with portable welding tongs, power being supplied by a suitable transformer. On exhaust tubing up to 0.200 in. in diameter manually operated tongs can be used. On larger sizes mechanically operated arms are required to collapse the tubing and to furnish the necessary push-up as the tubing becomes plastic under the welding points.

In manufacturing the tubes illustrated in Fig. 1, the shells are drawn from sheet steel and are welded to the heads after the seals have been made and the mount has been completely assembled. A current of 50,000 to 60,000 amp. is required to make the weld.

Single-impulse projection welds are used extensively in welding seals to the headers of large tubes, such as the one shown in Fig. 4. Brazing is not desirable, as the mercury which is used in certain tubes may dissolve the brazing material and destroy the union. Complete assembly by resistance welding is essential. The seal is assembled as a unit, and welded after the glass work has been finished. This is an important economic factor in tubes of a limited production; standard seals can be stocked and welded to headers for the many different tube types.

Maximum possible size of projection weld is limited only by the welding machine and the practical maximum for the capacity of the power supply. For diameters greater than 2 in., seam welding is generally used, although the exact transition point from projection to seam welding must be determined by the economics of the particular case.

The design of welding machines for this class of service is of importance in obtaining consistent welds. The motion of the top electrode must not hammer and mushroom on the down stroke. Since high peak currents are required the reactance of the electrical system must be low. The transformer is mounted close to the electrodes and the loop formed by the welding arms is kept small.

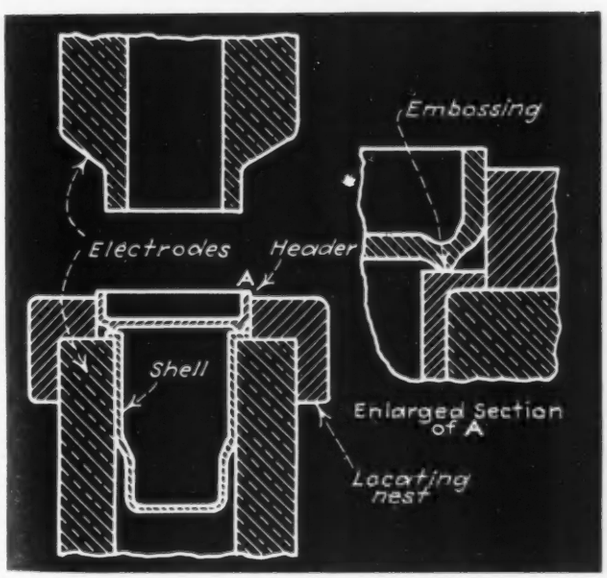


Fig. 3—Shell and header placed in the electrodes ready for welding. Only the projecting embossing is heated by the current, duration of which is electronically controlled

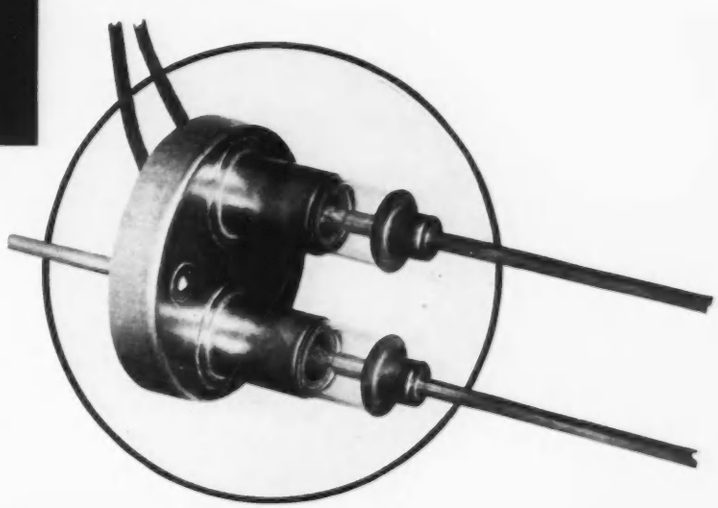


Fig. 4—Single-impulse projection welds are used extensively in welding seals to the headers of large tubes such as this one

Unbalanced Pull in Electrical Machines

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FOR designers who buy "engine-type" or shaftless motors and mount them on the shafts of their own equipment, maximum allowable shaft flexibility as well as deflection, shear or bending stresses determine the shaft size. Permissible shaft flexibility is limited by the unbalanced magnetic pull caused by the radial displacement of the rotor in the bore of the stator.

Stator bores and rotor surfaces cannot be made perfectly true, and a small initial inaccuracy or displacement results in an unbalanced pull that deflects the motor shaft. This deflection results in an additional pull which causes still more deflection. The deflection increases until the shaft reaction at some deflection d equals the magnetic pull at that displacement. The resulting unbalanced pull is therefore a function of the initial displacement. In terms of initial displacement g in the air gap G, the rotor diameter D and length L, all expressed in inches, and with a given flux density B on the pole faces, the unbalanced pull P is:

$$P = \frac{CDLB^2}{G} \times \frac{g}{[1 - (g/G)^2]^{3/2}} = K_1 \frac{g}{[1 - (g/G)^2]^{3/2}} \qquad (1)$$

If the maximum flux density is used in the equation above, assuming the flux to vary according to a sine wave, the constant C becomes 22×10^{-9}. This value is sufficiently accurate for use on induction motors. For salient pole motors the field form resembles a trapezoid. The constant C is determined from the ratio of maximum fundamental to actual maximum of field form. An average value of 26×10^{-9} is satisfactory for salient pole motors.

The deflection at which the magnetic pull equals the shaft reaction is found by equating the shaft reaction $K \times d$ in lb. per in. deflection with the magnetic pull as follows:

$$K \times d = K_1 \frac{g + d}{\left[1 - \left(\frac{g + d}{G}\right)^2\right]^{3/2}} \qquad (2)$$

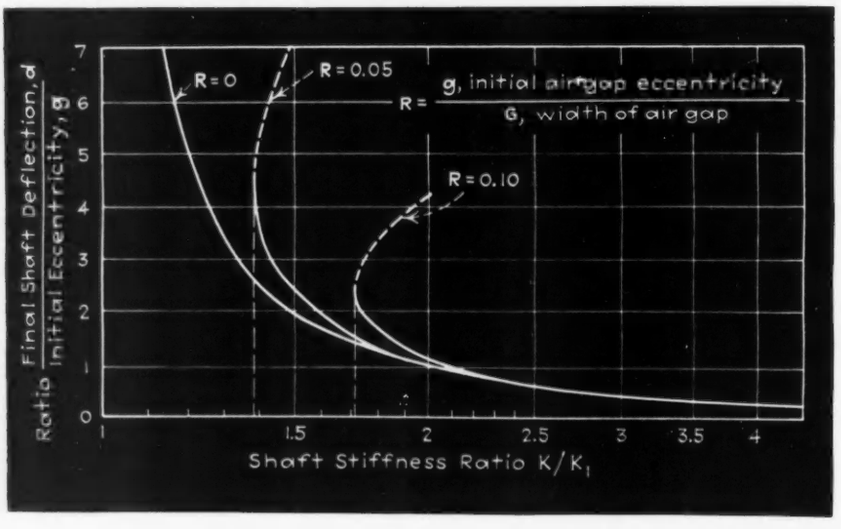
The solution of this relation for d gives the deflection for one set of conditions. Of more interest, however, is the relation between d/g, final shaft deflection divided by initial eccentricity, and K/K_1, the stiffness of the shaft divided by the magnetic constant of the design. The accompanying curves show d/g evaluated as a function of K/K_1 for various initial displacements g. With a value of 0.10 for the ratio g/G, the deflection is infinitely large for any value of K/K_1 less than 1.72. If the air gap is centered with the ratio g/G equal to 0.05, the deflection is stable when K/K_1 is as small as 1.38. The curve for $g/G = 0$ illustrates the condition approached as a limit when the gap is set with no eccentricity.

Unequal air gaps are the cause of vibration and excessive bearing temperatures. A small eccentricity of the rotor surface combined with an irregularity of the stator bore will produce an unbalanced pull varying in intensity. This unbalanced pull may be greater than the rotor weight, producing large deflections in the motor frame and bearing pedestals.

Vibration in higher speed machines may be caused by a decrease in critical speed as the result of the magnetic pull. In working directly against the shaft reaction the magnetic pull is in effect a negative spring constant that affects the critical speed.

Bearing temperatures also may be affected by the unbalanced pull which may exceed the rotor weight by as much as 100 per cent. Even though the bearings are liberally designed, unless they are self-aligning the load being non-uniform may cause overheating.

Limiting values for K/K_1 are difficult to establish because of the inaccuracies accompanying any calculation of this type. The calculation of K_1 is difficult because of the neglect of saturation and the effect of damping currents. A conservative design would use a value for K/K_1 greater than 3. If a value as low as 1.5 is necessary, every precaution should be taken to obtain an accurate air gap, and the effect of magnetic pull on the critical speed determined.



Effect of shaft stiffness and unequal air gap on the unbalanced magnetic radial pull in electric motors of the shaftless type

Steel Castings in Welded Structures

CLARENCE TOLAN, Jr.
Dodge Steel Company

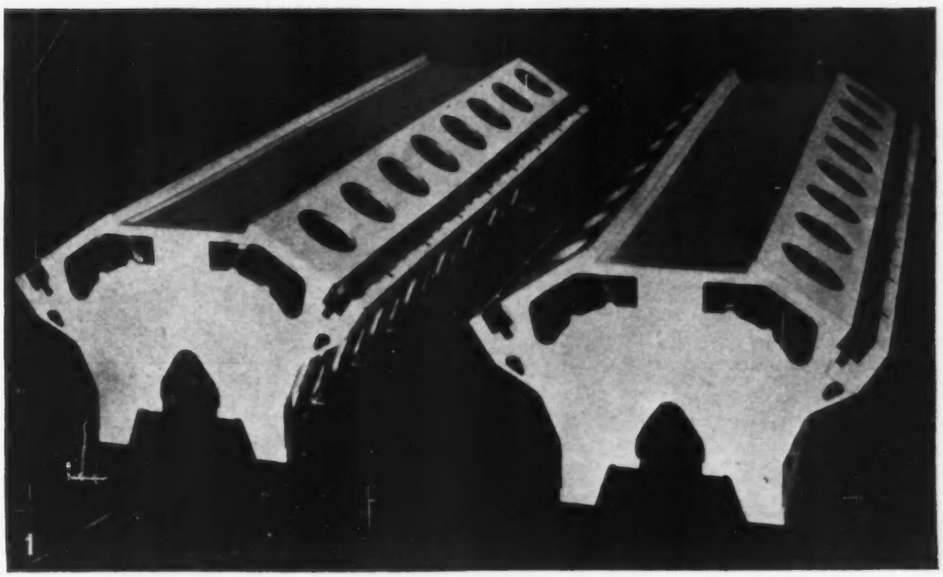


Fig. 1—Winton diesel engine crankcase with cam pockets of electric furnace cast steel electrically welded to steel plate

PROGRESS made during the past few years in the art of welding has resulted in the fabrication of many units by that method. As with many new developments, the limitations of welded structures were not fully appreciated and extravagant claims were made forecasting the substitution of welded structures for a large number of parts formerly made of cast steel or iron. But the loss to the casting industry has not materialized to any appreciable extent. The fabrication of welded structures has opened a new field for steel castings by virtue of the welding qualities of cast steel. Cooperation between welding engineers and foundry engineers has resulted in designing many parts to be made by welding steel castings to plate or structural shapes.

Since the cost of a finished job produced by welding increases directly with the number of separate pieces involved and the number of inches of welding required to join the pieces together, a steel casting can often be substituted for intricate welded shapes which would require many pieces and considerable welding.

Foundries can produce parts that are of a design more intricate than can be produced by other methods. By using steel castings for the parts that have intricate shapes and by taking advantage of the welding qualities of cast steel, economies can be effected and the finished article improved in appearance, strength and utility. Often the weight as compared to all-welded units can be reduced without sacrificing strength and rigidity.

Design necessarily requires a knowledge of the strength of the material employed. While the strength in the casting material is related to a combination of composition and heat-treatment, the founder must take all possible precautions to insure a design that will lend itself to casting without creating defects or points of stress concentration which would impair the strength of the casting.

In the accompanying illustrations are shown some applications of castings to welded structures. Fig. 1 shows a crankcase for diesel oil engines manufactured by the Winton Engine Corporation. The cam pockets are made of electric furnace cast steel and are electrically welded to steel plate. In Fig. 2 is shown one of the series of steel castings used in these crank cases. In Fig. 3 is shown a bed plate with cast steel bearing supports welded to steel plate. In Fig. 4 is shown a charging box, the ends of which are steel castings.

One of the primary requirements for steel castings to be used for welded structures is the chemical composition. The suggested range of chemical composition in straight carbon steel for castings to be used as integral units in a welded structure, is as follows:

Carbon	0.17 to 0.25 per cent
Manganese	0.50 to 0.80 per cent
Silicon	0.25 to 0.40 per cent
Phosphorus	0.06 max.
Sulphur	0.06 max.

Experience has shown that castings of this composition can be successfully welded to steel shapes and plates. The rolled steel used is generally of lower

carbon, manganese and silicon content than that specified for cast steel, but as a result of mechanical refinement of grain size the rolled steel has somewhat higher physical properties than a cast structure of identical chemical composition after being subjected to the effects of the welding operation.

Heat-Treatment

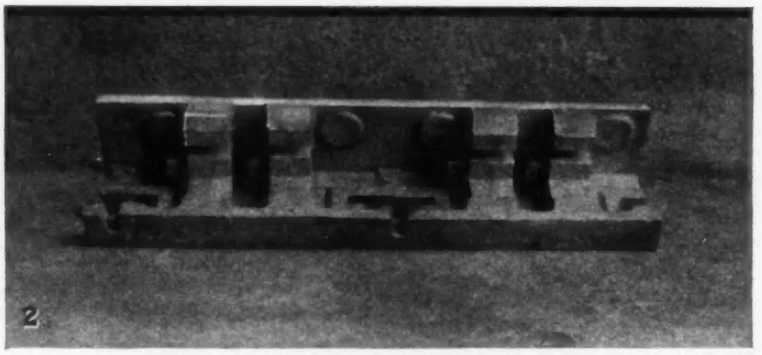
In all welded constructions the grain structure of both the cast and the rolled steel adjacent to the weld is changed, as a result of local heating to or through the critical range, followed by rapid cooling. This results in a marked modification of the physical properties of the metal. A local heat-treatment of the welded area is reported by competent authority to be of dubious value. The approved practice is to subject the completed fabrication to a suitable heat-treatment. The heat-treatment may be a draw at 1,200 to 1,250 deg. F. to relieve strains and partially correct the metallurgical structure; a full annealing at 1,600 to 1,650 deg. F.; or a straight normalizing from a similar temperature. A more complete treatment consists of normalizing and drawing. The nature of the heat-treatment is dependent on the shape, size and duty required of the structure. The higher temperature heat-treatments have the disadvantage of liability to scale formation. Many light weight, light section structures fabricated by welding will not stand the higher temperatures.

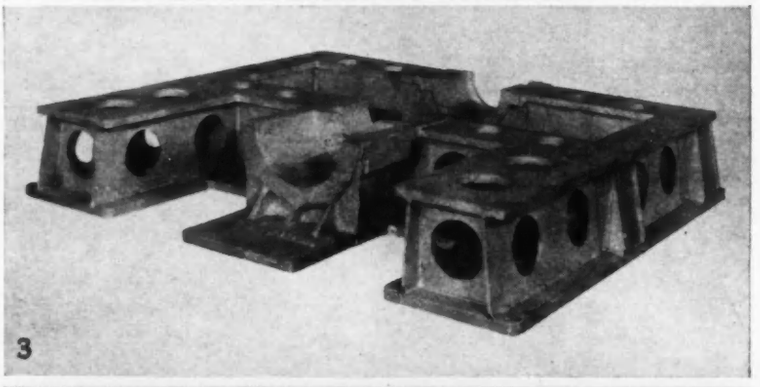
Castings which are destined to become parts of welded structures customarily receive a heat-treatment before delivery to the welder but it is an advantage to the founder to know what final heat-treatment is intended by the fabricator.

Physical Properties

Limits of chemical composition prescribed for plain carbon steel castings, in relation to the available heat-treatment, indicate physical properties of the castings as being:

Yield Point .....30,000 to 45,000 lb. per sq. in.
Tensile Strength ..60,000 to 75,000 lb. per sq.in.
Elongation in 2 in..35 per cent to 22 per cent
Reduction of Area.55 per cent to 30 per cent
Brinell Hardness .115 to 160





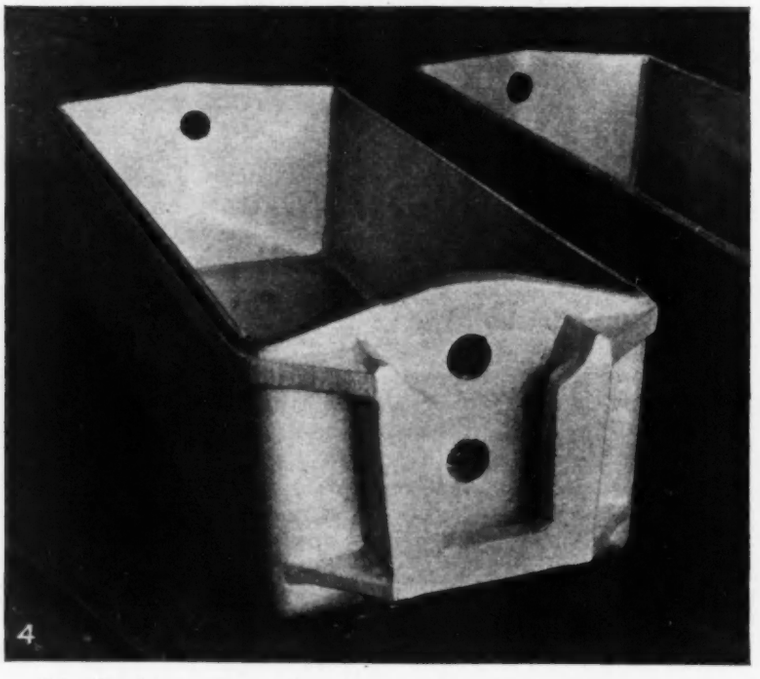


Fig. 2—One of the steel castings used in the Winton diesel engine crankcase. Fig. 3—Engine bed plate wherein the cast steel bearing pedestals are welded to steel plate. Fig. 4—Because of their intricate shape, the ends of this charging box are steel castings and are welded to the steel plate sides and bottom

Alloy steels are used in some light welded designs, but the practice for heavy structures and for structures subjected to high stresses is to use plain carbon steels of the types indicated. An internal crack in the region of the weld, resulting from an excessive carbon content, is tremendously more damaging than a slight recession of physical properties.

In the steel castings industry experiments are being conducted with the object of producing compositions which will give increased strength without impairing the true weldability of the metal. These comprise the use of alloying elements which are not readily oxidized, but there is obviously a limit which may not be exceeded because the hardenable alloys are not considered weldable by the makers of widely accepted welded structures.

Which Alloy for Die-Castings?

HERBERT CHASE

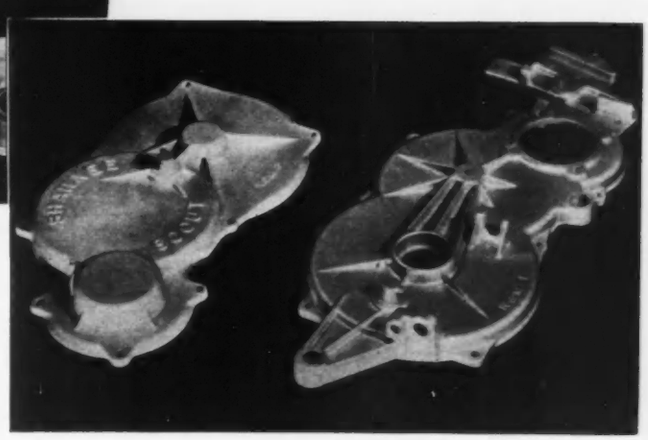
Through his numerous contacts with the die-casting industry, Mr. Chase speaks with a first-hand knowledge about the state of the art and the latest developments. His book "Die-Castings" has given him recognition as being well versed in the various ramifications of this subject

SIX base metals are employed today in producing die-castings. The alloys in each of the six basic groups have many similarities, but each alloy has certain properties more or less exclusive to itself.

Tonnage of castings in zinc alloys approximates about three times that of the other five types of alloys combined. Zinc alloys are not only the least expensive but they also possess many excellent physical properties, are easy to cast and the dies required are relatively inexpensive in both first cost and upkeep. Zinc die-castings are among the toughest of the commoner cast metals. Compared with other die-casting alloys, zinc alloys are second only to the copper alloys in tensile strength, impact strength, elongation and hardness, and are much less expensive than the copper alloys. In addition, zinc alloy die-castings can be produced with an exceptionally smooth surface finish which can be buffed ready for plating, sometimes without grinding or polishing.

When produced, as they commonly are, to the recognized A.S.T.M. specifications, the zinc alloys are free from the intergranular corrosion which was once a disadvantage. They are, however, subject to slight dimensional changes and to some change in physical properties with aging, but this is rarely of any significance. Use in contact with steam or in temperatures above 300 deg. F. is not recommended. Tarnishing results from contact with air and some surface oxidation occurs when moisture is present. But this rarely has any effect other than to change appearance, which can be largely avoided by any of several finishes.

Zinc alloy die-castings have gained wide use for automotive parts, for parts in electrical and other household appli-



(Above) A group of aluminum die-castings, except the tappet guide in the center foreground which is magnesium alloy. (Right) Two zinc die-castings, indicative of the size and complexity to which such castings can be produced

Nominal Composition and Properties of Die-Casting Alloys

Base Metal and Number	Nominal* Composition per cent	Tensile* Strength p.s.i.	Impact* Strength Charpy. ft. 11 ½x½in. bar	Elongation* per cent in 2 in.	Brinell* Hardness No.	Specific* Gravity	Remarks and Uses
Zinc ASTM 21 SAE 921 Zamak 2	Copper 2.73 Aluminum 4.13 Mg 0.3 Zinc bal.	44,000	14.0	9.0	80.0	6.75	Tensile strength increases and impact strength decreases with aging. (See text). Widely used for great variety of castings including automotive, home appliances, electrical machine, instrument, hardware and many others.
Zinc ASTM 23 SAE 903 Zamak 3	Aluminum 4.1 Mg 0.4 Zinc bal.	36,000	18.0	5.0	63.0	6.64	Tensile and impact strength remain practically unchanged with aging. (See text). Widely used for great variety of castings including automotive, home appliances, electrical, machine, instrument, hardware and many others. Min. dimensional change.
Aluminum ASTM V SAE 305 Alcoa 13	Copper none Silicon 5.0 Nickel none Aluminum bal.	33,000	2.0	1.5	80.0	2.66	Lightest of aluminum die-casting alloys. Good fluidity and free from hot shortness. Resistant to salt-water corrosion. Used for complex, thin-walled and large castings.
Aluminum ASTM IV SAE 304 Alcoa 43	Copper none Silicon 5.0 Nickel none Aluminum bal.	29,000	4.5	3.5	60.0	2.77	Resistant to salt-water corrosion. Has low yield point. Suitable for some aircraft-engine and marine parts.
Aluminum ASTM VI Alcoa 83	Copper 2.0 Silicon 3.0 Nickel none Aluminum bal.	30,000	5.0	3.5	60.0	2.75	Employed for maximum ductility as when bending swedging or similar working is required. Suitable for handles, levers and like parts.
Aluminum ASTM VII SAE 307 Alcoa 85	Copper 4.0 Silicon 5.0 Nickel none Aluminum bal.	32,000	2.5	2.0	70.0	2.78	Has best combination of strength and ductility of aluminum alloys. Relatively low in price. Used for general purposes and where good mechanical properties are required.
Aluminum ASTM IX SAE 309 Alcoa 93	Copper 4.0 Silicon 1.75 Nickel 4.0 Aluminum bal.	31,000	2.0	1.5	80.0	2.87	Whiter in color than alloys containing more silicon. Relatively high in cost and does not cast so readily as some other aluminum alloys. Easy to machine. Suited for parts to be polished if maximum toughness is not required.
Aluminum ASTM XII SAE 312 Alcoa 81	Copper 8.0 Silicon 1.5 Nickel none Aluminum bal.	33,000	1.5	1.0	70.0	2.85	Inexpensive general purpose alloy. Is most widely used of aluminum casting alloys.
Magnesium ASTM G	Aluminum 10.0 Magnesium 88.0 min	29,000 to 33,000	1-2	1-3	55-60	1.81	Lightest of all die-casting alloys, and used where light weight is most important, as in automotive (including aircraft) and portable machines.
Copper Yellow Brass	Copper 58.0 Zinc 41.0	65,000-75,000	35.0	15-20	120-130	8.47	Least expensive of copper die-casting alloys. Color yellow. Machinability fair. Corrosion resistance good. Bearing properties poor.
Copper "Brastil"	Copper 81.0 Silicon 4.5-5.0 Zinc bal.	90,000-95,000	36.0	10-17	160-180	8.05	One of strongest die-casting alloys. Machinability fair, corrosion resistance high. Bearing properties good. Has lowest melting point (1,600 deg. F.) of copper die-casting alloys.
Copper "Timicosil"	Copper 42.0 Zinc 41.0 Lead 1.0 Nickel 16.0	85,000-95,000		10-20	160.0	8.45	One of strongest die-casting alloys. Color light. Machinability good. Corrosion resistance high. Melting point 1,675 deg. F. Used for valve parts, hardware, etc.
Tin ASTM 1 SAE 10	Tin 91.0 Copper 4.5 Antimony 4.5	9,000		2.0	23-26	7.53	A very fluid babbitt having good bearing properties. Good corrosion resistance. Not easily tarnished. Usable in contact with food.
Tin SAE 12	Tin 59.5 min. Copper 3.25 Lead 26.0 max	7,800		1.25	27.7	7.98	Relatively cheap babbitt having good bearing properties at moderate pressures
Lead SAE 13	Lead 86.0 Tin 4.5-5.5 Antimony 9.25-10.75	13,800	0.6	10.5	23.2	10.24	Cheap babbitt suitable for carrying light loads
Lead "C. T. Metal"	Lead 83.0 Antimony 17.0	6,600	0.2	4.5	17.0	10.5	Cheap babbitt Also used in making coffin trim parts. Does not tarnish quickly.
Lead ASTM 5	Lead 90.0 Antimony 10.0	7,700	0.8	15.5	15.5	10.65	Used for battery parts and fire extinguisher parts, because of good corrosion resistance, and for weights.

*Note: Tabular data are as given in general information in the ASTM or SAE specifications or are taken from information furnished by the makers of the base metals or the alloys made from them. For detail composition, including allowable impurities (which are highly important in the case of the zinc alloys in particular) reference to the complete specifications should be made. Some of the specifications referred to are only tentative.

ances, office and store equipment, instruments, small tools, hardware, toys, sporting goods, and in a wide range of novelties and jewelry.

Aluminum alloys are second only to zinc in extent of use. Their tensile strength is only slightly lower and they have a distinct advantage for those applications where light weight and dimensional stability are important. In addition, some of the aluminum alloys take a high polish which they hold for considerable time and they can be ball burnished at little cost. A finish coating is unnecessary, even where with some of the other alloys it would be required to prevent rapid tarnishing. Sometimes this is an important cost item. Impact strength is lower than for zinc alloys, but is adequate in most applications. The relatively high melting point of aluminum alloys makes them suitable for use at temperatures well above those for which zinc alloys are recommended. On the other hand, it necessitates the use of alloy steel dies which require heat-treatment and are more expensive than the carbon steel dies generally used for zinc. In time the higher temperature causes checking even of the alloy steel, and this in turn makes redressing of the dies necessary if a smooth surface finish is to be maintained on the castings. Some aluminum alloys take beautiful anodic finishes and high-bake enamel finishes having good adherence and excellent endurance. Plated finishes can also be applied.

Aluminum die-casting alloys are used especially to gain light weight, as in aircraft and on portable equipment. They are useful also for parts that come in contact with foods, for parts in instruments, machines and electrical equipment, including motor housings and armatures, and in many domestic appliances.

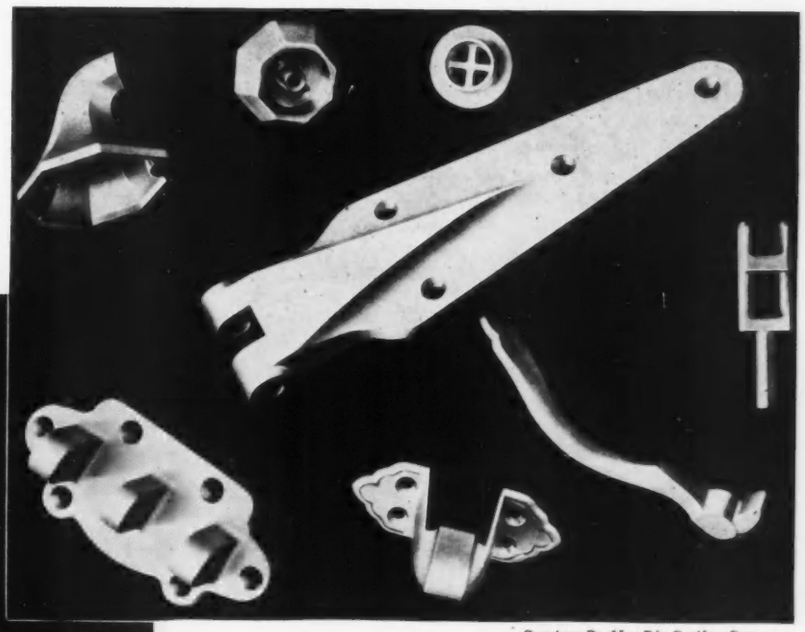
Alloys having a copper base are the strongest of all those used in die-casting and are also high in corrosion resistance, but are considered the most difficult to produce and are higher in cost. They require a special type of casting machine and, compared with zinc and aluminum, the number of producers in this country is much smaller. To minimize the deterioration of the dies caused by the high temperature at which the copper-alloy castings are made, the material is fed to the dies in a plastic rather than a fluid state. But even so, rather expensive alloy-steel, heat-treated dies are required and frequent redressing is necessary to maintain a smooth finish. This largely accounts for the relatively higher cost of copper-alloy die-castings. In consequence, their use is limited to applications in which the physical and other good qualities of the castings outweigh the higher cost. Copper alloy die-castings are being used more extensively for gears, brackets and machine parts where strength is required.

Tensile and impact strength of copper die-casting alloys are as much as double those of the zinc alloys. Although excellent plated and other finishes can be applied, the corrosion resistance of the unplated castings is high and many castings, as indeed with other alloys, are used without finishing. With copper-alloy die-castings polishing costs are likely to be high as it is difficult to maintain a smooth cast surface finish without frequent redressing of dies.

Lead and also tin-base alloys, once very widely used, have recently been displaced in many applications by the stronger and less expensive zinc alloys or some of the other types. Low melting point makes for easy casting and long die life, but the low tensile strength and low impact strength of these alloys, together with other factors, limits their use chiefly to applications in which the cor-

(Right) Copper alloy die-castings are used where strength is a controlling requirement. They also are highly corrosion resistant and have a good surface finish

(Below) Die-cast aluminum parts for a surveyor's transit, for which light weight is a strong sales point



Courtesy Doehler Die Casting Company

rosion resistance of the alloys is a leading requirement, and strength, weight and finish are of no particular consequence. Extremely close dimensional limits can be maintained with tin base and lead base alloys, and this is sometimes a factor in their selection, as is also the good bearing properties of some of these alloys. Antimonial lead alloys are used for some cheap novelties, because of the bright and comparatively nontarnishing quality of the cast or polished surface. Lead alloys are highly resistance to corrosion and are even used in contact with some acids, as in storage batteries. High specific gravity also accounts for the use of some lead die-castings.

Tin alloys are employed for parts in contact with foods, as in milking and some other machines. They are also used where a good bearing metal is required; or where, as in counter wheels and similar small parts, dimensional exactness, and in some instances also corrosion resistance, is desired. As the tin alloys are rather expensive, their use is usually limited to parts that are relatively small.

Magnesium die-castings are used for applications in which a metal still lighter than aluminum alloys is needed. Strength of magnesium alloy (Dowmetal) is about the same as that of aluminum alloys. The castings are similar in appearance and can be produced on similar machines, though some special provision is required for keeping the molten metal out of contact with air. Castings darken with aging and are often given an applied finish, but plating technique has yet to be developed.

Properties of Zinc Alloys

Choice between the two zinc alloys covered by A.S.T.M. specifications often rests with the die-caster, but it should be noted that the No. 23 alloy, though having a lower tensile strength than the No. 21 alloy, has a higher impact strength, and is less affected, both in properties and dimensional change, than the No. 21 alloy. Impact strength of the No. 21 alloy has been found to decrease to about one-third its original value in three years of indoor aging, whereas tensile strength increases somewhat. Impact strength of the No. 23 alloy remains virtually constant, and there is practically no reduction in tensile strength.

Both of the A.S.T.M. zinc alloys undergo a slight shrinkage during the first three or four weeks after casting, unless given a simple stabilizing heat-treatment. Thereafter, a slow and, for most applications, an unappreciable growth takes place. In the No. 21 alloy the growth in three years of indoor aging is slightly less than 0.00037 in. per in. of length and in the No. 23 alloy is only 0.0001 in. per in. This is so little as to be negligible in all but a few exceptional applications.

Aluminum Alloy Specifications

There are five aluminum die-casting alloys covered by A.S.T.M. and S.A.E. specifications. In addition to these, two or three others are sometimes used. Certain of the physical properties which might determine the selection of the alloy are given in the table on page 380. If there is any choice, it is usually left to the die-caster, who is likely to have certain preferences based on ease of casting. The following items, based largely on information given in connection with S.A.E. specifications, may be considered in making a choice between the aluminum alloys:

S.A.E. No. 304—Withstands salt-water corrosion well. Has a low yield point and is not generally used where great strength or stiffness are required. Is suitable for some aircraft-engine and marine parts.

S.A.E. No. 305—The lightest of the aluminum alloys (specific gravity 2.66) and is especially resistant to salt water corrosion. Good fluidity and freedom from hot-shortness makes it suitable for thin-walled and for complex castings having both light and heavy sections, as well as for large castings. Can be softened by annealing.

S.A.E. No. 307—Affords the best combination of strength and ductility obtainable in aluminum die-castings and is a relatively low-priced, general-purpose alloy. Is used for pieces of relatively heavy section and where good mechanical properties are required, as in levers, frames, brackets and the like.

S.A.E. No. 309—Is whiter in color than alloys containing more silicon and well suited for parts to be polished or machined if maximum toughness is not essential. It is relatively high in cost and does not cast so readily as S.A.E. No. 305 and A.S.T.M. No. VI. It machines readily.

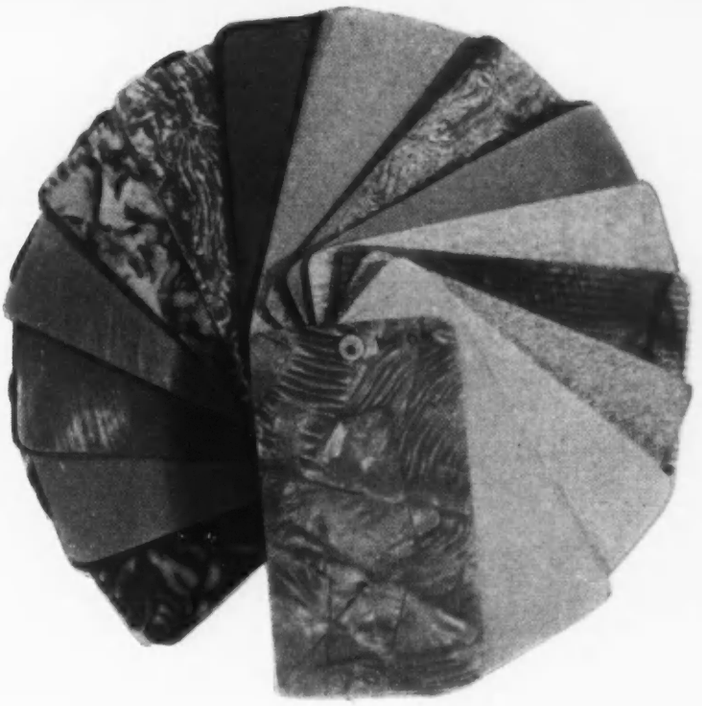
S.A.E. No. 312—Is an inexpensive general-purpose alloy commonly known as "No. 12," and is in wider use than any other aluminum die-casting alloy.

A.S.T.M. No. VI—Is used where maximum ductility of the finished part is desired or where its production involves spinning, swedging, bending or other deformation, as in levers and handles.

Choice between the various copper alloys is usually made on a basis of cost, physical properties, color, and corrosion resistance. Yellow brass having a nominal composition of 40 per cent zinc and 60 per cent copper is about the least expensive, but is less strong and does not have the bearing properties of some of the other alloys, as shown in the table. The alloys having considerable proportions of silicon or nickel are light in color, high in corrosion resistance and are among the strongest, some of them approximating a mild wrought steel in their tensile strength.

1935 PRODUCT DEVELOPMENT SURVEY NUMBER

IF YOU want to find out if there is any precedent for the design changes that you are contemplating, look for it in November *Product Engineering*. Here you will find what engineers in your field and allied fields are doing. More than 400 engineers have contributed to this report; more than 100 have been interviewed • • • • • November *Product Engineering* will be valuable for reference. It will serve as a guide book for design improvements that increase the salability of your product. Charts and tabulations, pictures and text will tell how the engineers of more than 400 leading companies improved the design of their products.



Examples of standard colors available in Pyralin, indicative of wide range of colors available in plastics

Plastics in Colors That Consumers Prefer

HOWARD KETCHAM
Color Engineer

As consulting color engineer for E. I. du Pont de Nemours & Company, the author has styled the colors for many of the plastics they manufacture. In this article he tells how to make certain that the colors selected will conform to consumer preferences

THE suitability of color and material to product and market is tremendously important. Unfortunately, there is no set rule for scientifically predetermining a given psychic reaction to a certain color. Color has no meaning in itself. It is only the continued association of colors with certain events that have established meanings for them.

Survey information, available on the basis of tests to determine the colors that consumers associate with various commodities, show that preferences depend not only on the color but also on the chroma, the degree of purity of the color. An olive green is a color of weak chroma, whereas an emerald green is classified as a color of strong chroma.

Strong chroma colors appeal best when color is chosen on the basis of appearance alone, without reference to taste or harmony. Men like blue, and women prefer red. In general, men prefer cool colors and women like colors in which red predominates. Both men and women dislike yellow and orange, but yellow is frequently preferred by young people. With men, red is second choice and with women, blue is second choice. Consequently, it would seem that a product to be sold to men and women should be either red or blue or a combination of these two hues. However, if all manufacturers adopted this plan, and a newcomer should introduce a product finished in green, he would have a market-individuality advantage.

An important advantage in merchandising is the ability to select colors of fashion appeal and to know when to introduce new colors. Unfortunately, color styling cannot be condensed to a mere use of formula. It involves too many interrelated factors to ever become a slide rule proposition.

It never pays to be ahead of fashions; running an experimental station in place of a showroom. Colors people are going to want next month or next year cannot be determined with any degree of certainty without first making a careful study of current trends. Such studies, coupled with an intensive analysis of the colors being promoted and observations of the consumer's actual reaction to potential style colors, produce the most reliable results.

Production color convictions often are based upon the guesswork of committees composed of buyers and stylists. When only the colors the committee have decreed are displayed, consumers are diverted from their preference and are obliged to select from available stocks. Buying preference should be elicited from customers by means of surveys. The effectiveness of mass surveys would not be complete without the especially devised Munsell Color Charts. With the use of these helps, the classification of consumers' color wants in hue, value and chroma can be disclosed.

In products where color is a factor, the sales staff must know when a change in consumer color acceptance

Examples of the wide diversity of plastic products in colors that are obtainable in Beetleware

is about to occur. Color forecasting is a methodical study of a situation, built on consumer preference which must first be obtained. Color leadership is too costly unless it represents what people want after their wants have been made known completely.

In Great Britain there has already been established a color counsel for the purpose of achieving cooperation between allied industries in the standardization of color to limit the speculative element in color decision. The National Research Council of Canada, and the Danish National Standards Committee have also expressed an active interest in color projects of this nature.

Many methods have been devised to register the color preferences of the masses, but they have proved only partially successful. Some style specialists feel that a report indicating red as a style favorite for dinner ware sets of urea resins is sufficient. But color reactions are specific. For this reason, it is essential to predetermine the exact hue of red that the market will accept from among the five color families in which red appears. These range from yellow-red-yellow to red-purple-red. In each hue, there are variations of value and chroma to be approved.

With no two manufacturers pulling together on the same color of red in the synthetic materials they are building into kitchen clocks, egg beaters, curtain rods, dinner ware and refrigerator hardware, the problem of finding items of various "makes" that can be used together in the same kitchen has become acute.

A concrete example of the serviceable value of an efficient color survey is disclosed by the results produced by the Color and Design Association of America, a service organization that makes color surveys. Sales of nitro-cellulose boudoir sets for the previous year showed a market acceptance for jade, rose, and maize in the order listed. When a color survey showed a consumer preference for coral, lilac, turquoise, and gold, in the order listed, the change was made. Results were gratifying.

The comprehensive color analysis by determining the colors to which the public is most susceptible makes possible smaller inventories and confines patterns to the most salable ones. Constant analysis of what the public has favored and is favoring, makes it possible to change well in advance of the saturation point.

By using materials such as plastics in which a wide range of color choice is available, and by predetermining through surveys the colors under consideration which are most likely to sell, more profitable results are bound to accrue.

Synthetic plastic materials are important in modern industry for three principal reasons.

1. They afford a practical medium for reproducing worthwhile color effects.
2. The limitless range of adaptations is encompassed in various plastic formulations.
3. They afford the age of color with the product of the age, obviating the need for delving into materials of the past.

To compete forcefully in modern markets, products must have color, novelty, and fashion. Almost any color, and countless special effects embodying three or four combinations of color, are available in one or more types of plastic materials. In order to provide color appeal, it is almost certain that plastics can be employed in some forms.

Color, through synthetic materials, has already transformed the fountain pen business from a utilitarian to a style commodity. Building a sales increase of more than 50 per cent since its introduction, millions of wood heels are now successfully colored in scuff-proof Pyralin.

Plastics can be adapted to a wider range of fabricating methods than most industrial materials. They can

also be easily polished, embossed, printed, lacquered, stained, and decorated in many ways. Thus, the opportunity for introducing color in varied new fields is wide open.

Plastics afford an opportunity of expressing quality and identity in products through color. The unusual color distribution embodied in early American glass has served recently as the inspiration for a number of plastic articles. The colors of the period in which that glass was first made (1840) were dressy and gay. Such colors are appropriately in keeping with the spirit that again prevails.

The present vogue for clear bold colors in the home to express elegance and distinction has been incorporated in the motif of a number of toilet ware articles of style appeal.

Harmony of color is the fundamental of beauty in design just as rhythm is the fundamental of music. Color harmony consists of various colors produced in a modified form so as to produce a pleasing whole, but color harmony exists only where there is a common color present. Associated combinations of harmonious colors are pleasing, restful; and are used more than any other combinations in plastics. In all plastic work, the essential objective is to employ color in order to render the attractive points of the merchandise more prominent.

Fading colors are a great disappointment. In plastics, as in most other materials, the fugitive colors are: pink, violet, light blue, light maroon, purple and magenta. These should be avoided in products for outdoor exposure.

Certain colors placed side by side hinder or help each other. To be really effective, color must represent a series of contrasts. For example: a full hue strength of red alongside of a dark rich purple will appear rich and interesting, but if the same red be viewed alongside of a lighter purple, the result will prove harsh and unattractive.

In all instances of the harmonious arrangement of colors, the question of relative strength must be seriously considered. Yellow is the lightest color and violet the darkest. Between these two extremes are two groups, one red and the other blue. As long as the yellow used with red or orange is lighter, the effect will be good. Blue should be lighter than green, and violet the darkest color in any combination, unless discord is purposely sought.

Beautiful gray effects can be produced in synthetic plastics by blending bright colors instead of thinning weak colors to produce gray. The limpid quality of Sevres Cobalt blue makes it an ideal color for gift boxes in plastics, particularly when inlaid with silver or yellow metal.

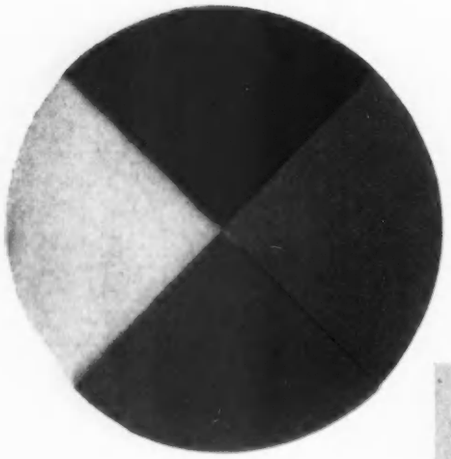
Because blue is such an idealistic color, it should be used in proportion to its own power to move people. For objects such as automotive dashboard buttons, gearshift balls, and door handles, blue is an unwise choice, because it tends to disappear from sight at dusk. Orange, red, and violet are better plastic colors where visibility is essential. Yellows and reds are always brighter than blues, greens, and purples. Green is a splendid utility color in its pure state.

Plastic colors that are distinctive looking help to fix trade-mark impressions on the memory. In this connection, color should be significant of the product.

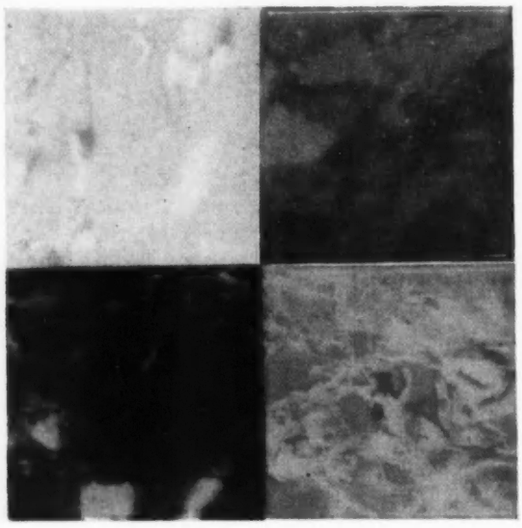
Surveys reveal that certain hues have greater remembrance value than others. For example, a certain dark blue invites the greatest attention and has the greatest remembrance influence on women. Dark greens of a particular hue have the least influence upon women. Purple of a specific hue, value, and chroma has the greatest remembrance value on men.

The use of plastics in colors having the maximum influence on memory stimulation for men or women is more important on higher-priced merchandise. The correct choice of color in this way serves to identify

This Textolite kitchen clock, designed by Ray Patton for the General Electric Company is in a color that many women favor



Consumer color preferences are disclosed through actual surveys. Here are examples of some of the solid colors obtainable in Pyralin



The trend toward things purely American has lead to the reproduction of early American glass in plastics, these being a few examples of the striking effects that are attained

products in a most helpful way, thereby creating a higher display and consequently a lower selling cost.

No color can be beautiful at all times and in all places. Each color is beautiful in its own way in certain appropriate environments and relationships. A color that is excellent for a kitchen clock would hardly serve equally well as the color for a boudoir accessory. At the present time, Texolite kitchen clocks sell best in a certain ivory. Next in order of preference comes green, black, red, blue, orange, and yellow. For boudoir use, black alarm clocks outsell ivory two to one.

Color associations play a major rôle in the selection of colors for packages, advertising, and merchandise displays. Color and chroma that are shown to be the most appropriate for the following products are: (1) building supplies—yellow and orange (weak chrome); (2) jewelry— yellow and purple (strong chroma); (3) breakfast food—yellow and orange (strong chroma); (4) perfume—yellow and purple (weak chroma); (5) coffee—yellow and orange (weak chroma); (6) soap—yellow and green (strong chroma); (7) candy—red and yellow (strong chroma).

In selecting colors for products, look first for the æsthetic possibilities. Consider next the ultimate purpose and environment, and last, but by no means least, determine by means of an adequate survey the colors to which the market is most susceptible.

The color effect to be used is determined to a degree by:

1. The surface texture required.
2. Whether object is to be viewed from near or far.

Brilliant colors look best out of doors where they can be seen from a distance, because distance lessens the apparent intensity of colors.

In selecting color for a market, it should be recognized that:

1. People are repulsed by inharmonious colors. Strong color contrasts tend to create tension.
2. Contrasts are more pronounced between a warm color and a cool color (red and green).
3. Colors can be moderated in their effect by hue, value, and chroma changes.
4. Light, cool colors make objects appear larger.
5. When complementary colors are placed near each other, they appear to be more intense (orange and blue; purple and green-yellow; purple-blue and yellow are complements).
6. Surprise effects should be used for securing attention, because new aspects are won through color change. For example, red plastic heads on clothing dummies command attention.

The subconscious influence of appearance appeal is today recognized as the most potent force in modern selling. Three-fourths of this appeal depends entirely upon the discriminating use and choice of color.

Plastics Suitable for Color

Manufacturer	Trade Name	Remarks
Celluloid Corporation DuPont Viscoloid Company Fiberloid Corporation Nixon Nitrate Works	Celluloid Pyralin Fiberloid Nixonoid	Nitro-celluloses Good color medium Inflammable
Celluloid Corporation DuPont Viscoloid Company Tennessee Eastman Corporation	Lumarith Plastacele Tenite	Cellulose acetates Good color medium Non-inflammable
American Plastics Corporation	Ameroid	Caseins Good color medium Non-inflammable
Union Carbide & Carbon Corporation	Vinylite	Vinyl resins Good color medium Non-inflammable
American Cyanamid Company Toledo Synthetic Products, Inc. Unyte Corporation	Beetleware Plaskon Unyte	Urea resins Good color medium Non-inflammable
Bakelite Corporation General Plastics Richardson Company Resinox Corporation General Electric Company American Record Company Colt's Patent Firearms Company Stokes & Smith Company Reilly Tar & Chemical Company	Bakelite Durez Insurok Resinox Textolite Arcolite Coltrock Durite Indur	Molded phenolic resins Very strong Limited color range Non-inflammable High dielectric strength
American Catalin Corporation Marblette Corporation The Celluloid Corporation Fiberloid Corporation	Catalin Marblette Ivaleur Fiberloid	Cast phenolic resins Soft and easily carved Limitless color range
Westinghouse Electric Company Formica Insulation Company General Electric Company Mica Insulator Company Panelyte Corporation Richardson Company Synthane Corporation Continental Diamond Fibre Company National Vulcanized Fibre Company Spaulding Fibre Company Taylor and Company	Micarta Formica Textolite Lamicoir Panelyte Insurox Synthane Dilecto Phenolite Spauldite Phenol Fiber	Good color medium Fire-resisting Laminated plastics

QUESTION AND COMMENT

Effect of Pipe Length on Bursting Pressure

VICTOR TATARINOFF
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● When shear or torsion test specimens do not correspond with actual designs, the test data must be used with caution. As explained in the article, "Effect of Specimen Length on Test Data," on page 347 in the September number, correction factors must be applied for the effect of length on torsional specimens.

Length of specimen also affects the bursting strength of pipes subjected to internal pressure. Bursting strength S is generally calculated from P the pressure in lb. per sq.in., the inside diameter d and the wall thickness t of the pipe, using the relation,

$$S = \frac{Pd}{2t}$$

From tests on welded steel tubing, published in the U. S. Bureau of Standards *Journal of Research*, April, 1930, bursting strengths were calculated using this formula. The welded tubes were 1 in. and 2 in. in outside diameter with a length of 12 in. In the table is a summary of the tests and additional data on bursting strength of seamless steel tubing ranging from 3 to 6 in. in diameter.

From the tabulated data, metal in the 2 in. pipes, although welded and subjected to compound stresses, proved stronger than similar material subjected to simple tension. Seamless steel pipes were from 2 to 4 times stronger than the material subjected to tension. Also, the ratio of bursting strength to ultimate tensile strength decreased with increase in the ratio of pipe length to diameter.

Differences in strength shown in the table are attributed to the effect of reaction forces arising at the end fixtures. For a tube fixed at the ends any deflection produces a reaction at the ends. Therefore, the resistance to deflection or to any circumferential elongation of the tube material can be calculated from the following formula comprising all elements in the resistance of tube wall to inside pressures.

$$P = 0.89S\frac{2t}{d} + \frac{1.92\,EI}{l^4} \times \frac{D}{d} \times e$$

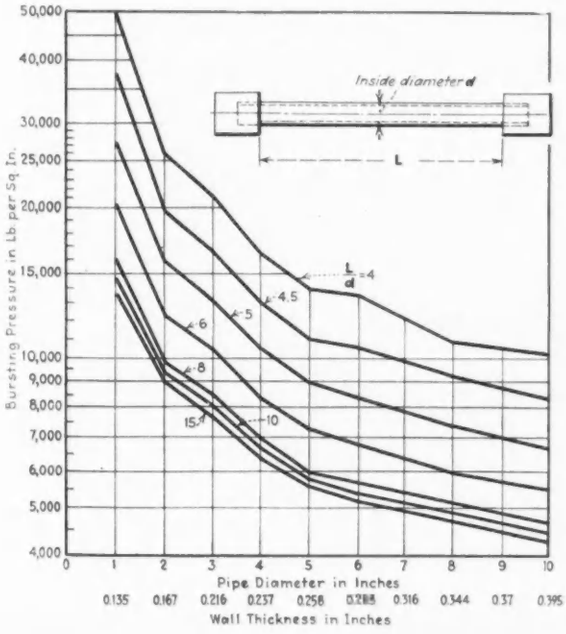
In this relation, l is the length of pipe between supports, D is the outside diameter, E is the elastic modulus and e the per cent elongation for the material. For a hollow semicircular section, the moment of inertia I, in terms of the outside radius R and the inside radius r, is,

$$I = 0.11(R^4 - r^4) - \frac{0.283\,R^2r^2(R-r)}{R-r}$$

Applying the above relation for P to the data in the table, the calculated bursting pressures are within 5 per cent of the values determined by experiments. To facilitate application of the equation, curves shown to the left determine internal pressures at which pipes will burst. The curves are constructed on basis of 27,000,000 for the elastic modulus, 60,000 lb. per sq.in. for the bursting strength, and 20 per cent for the elongation for standard steel pipes suitable for 400

Calculated Bursting Strength and Tensile Strength of Pipe

Outside Pipe Diam. In.	Wall Thickness In.	Length In.	Bursting Pressure lb/sq.in.	Calculated Bursting Strength	Tensile Strength lb/sq.in.	Ratio of Bursting to Tensile Strength	Ratio of Length to Diam.
2	0.035	12	2,300	63,600	58,000	1.100	6.0
2	0.050	12¾	3,200	61,050	60,140	1.015	6.4
2	0.062	12	4,000	60,500	59,400	1.018	6.0
2	0.081	12	5,400	61,250	60,900	1.003	6.0
3½	0.157	22	6,100	57,000	61,000	0.933	6.3
4¼	0.216	22	7,100	62,500	61,000	1.025	5.2
5¼	0.236	22	16,400	163,000	61,000	2.67	4.2
6¼	0.307	22	20,000	202,000	54,000	3.74	3.5



For standard pipe bursting strength increases with a decrease in ratio of length to diameter. A ratio of 8 corresponds to the conventional formula

lb. per sq.in. working pressure. The same graphs can be applied with a certain degree of approximation to pipes having other wall thicknesses. For that purpose, values of P estimated from the curves are multiplied by the ratio of the thicknesses. For example, a 25 in. length of 5 in. seamless steel pipe having a wall thickness of 0.258 in., the bursting pressure corresponding to an L/d ratio of 5, is 8,900 lb. per sq.in. For a pipe of similar dimensions, but with a thickness of 0.375 in., the ratio of 0.375/0.258 is 1.315 which multiplied by 8,900 gives 11,700 lb. per sq.in. for the bursting pressure. This value is much higher than the pressure of 9,000 lb. per sq.in. derived from Equation (2). This relation therefore applies only for a value of 8 for the length to diameter ratio.

Increasing Sensitivity of Bimetal Thermometers

J. BLAIR DOWDEN

Development Engineer, Weston Electrical Instrument Corporation

● As compared with other methods of temperature measurement and thermostatic control, the use of a bimetal strip has inherent advantages of simplicity, durability and rapidity of response. In the design of bimetal elements for thermometers, however, serious limitations arise in providing accurate deflection over an easily legible scale.

For small deflections with changes in temperature, the straight bimetal strip is a satisfactory structural form. Such a straight strip is of limited use in temperature measurement, however, since a 4-in. length of a common type of bimetal 0.06 in. thick deflects only 0.002 in. per deg. F. at the free end of the cantilever.

To obtain greater deflection within a reasonable space the strip is commonly wound into a helix or spiral, the angular deflection at the free end actuating a radial pointer over a sector of a circular scale. As the developed length of the strip is increased, other structural variables will be introduced.

Both helical and spiral forms of bimetal elements are structurally weak resulting in a distortion of the coil form as length is increased. Since deflection is inversely proportional to thickness, rigidity obtained with a thicker strip offsets the original reason for lengthening the coil. Increased width of the strip not only increases the weight and the space required, but also increases inaccuracies due to bending across the width of the strip.

Internal flexion in a bimetal spiral is such that a temperature lag of several degrees may be set up before the pointer indicates a change in temperature. The shift in the center of rotation accompanying changes in spiral form may introduce further errors.

For a helical form, the effect of internal flexion is much less than for a spiral of equal sensitivity, but the greater structural length of the helix introduces other defects. Increased length requires a shaft to support the working end, which introduces friction. Temperature changes produce an axial as well as a rotational movement of the helix, varying the distance of the pointer from the face of the dial.

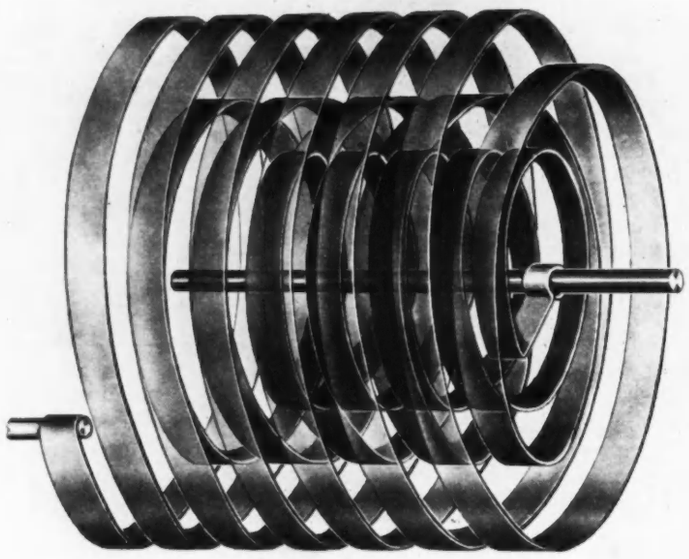


Fig. 1—In a bimetal thermometer element, the multiple helix form combines high sensitivity and structural rigidity

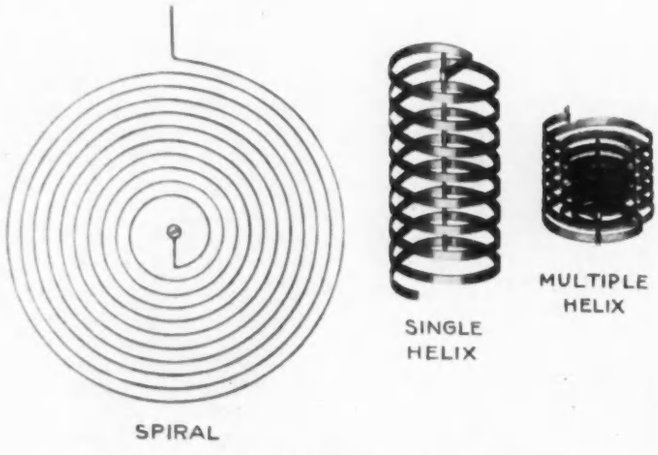


Fig. 2—Relative size of three types of bimetal elements having the same torque and deflection

Thus, a satisfactory bimetal element giving large deflections requires:

1. Increased developed length of strip within a smaller space.
2. Increased rigidity to eliminate distortion of the coil form and the necessity for a pointer bearing.
3. Elimination of axial displacement of the moving end.

To meet these requirements, the bi-

metal element shown in Fig. 1 has been developed by winding a single strip in the form of concentric helices. The several coils are additive in rotational deflection, but the axial displacement is mutually counterbalanced between the coils.

Obviously, the developed length of strip can thus be increased without lengthening the coil, resulting in a more compact element, and one in which lateral flexion of the coil, and consequent displacement of the axis, is materially reduced. Moreover, a coil of the necessary developed length will be sufficiently rigid to permit the pointer to operate without a supporting bearing.

Reduction in strip width and thickness made possible by this structural form permits the construction of thermometers of sufficient deflection to give accurate indications over a long scale from which fractions of a degree may be read. Yet, the thermal element itself need be no larger than the bulb of a common glass thermometer. Or, a unit can be constructed with sufficient torque to operate control devices or display thermometers with hands up to 6 ft. in length without introducing serious errors caused by deflection across the width of the strip.

As an example of the relative size and structural rigidity of the old and new types of bimetal elements, Fig. 2 shows the comparative size of three elements having the same deflection and torque.

Tests made both here and abroad on thermometers of this type show that the concentric helix form of bimetal element is of sufficient accuracy to be regarded as a measuring instrument of scientific standing. Even for inexpensive thermometers for the usual "household" range, for instance, accuracy to within ½ of 1 deg. F. can be expected.

Spring Length

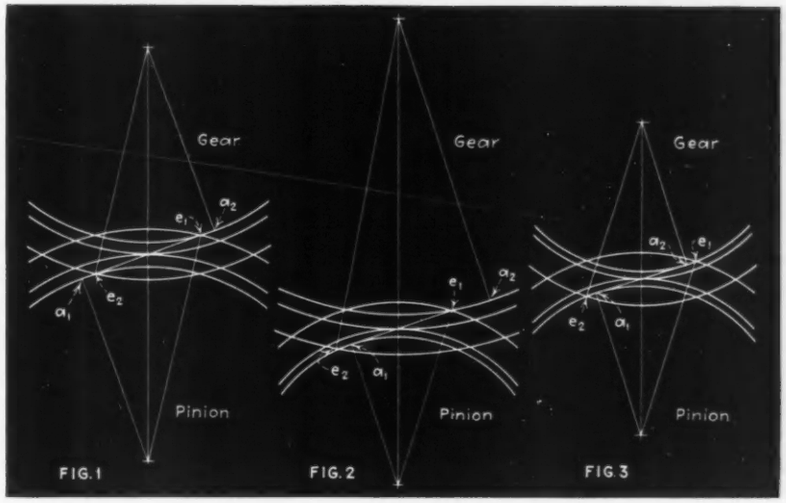
● *To the Editor:*

Assuming that the deflection is proportional to the load, the free length L_f of a helical compression or tension spring is:

$$L_f = \frac{P_1 L_2 - P_2 L_1}{P_1 - P_2}$$

The length L_1 of working coils corresponds to load P_1, and length L_2 corresponds to load P_2. If the free length of a tension spring is the solid height, it is assumed that the spring is not under initial tension. This relation is independent of wire size and the pitch diameter of the spring.

—STILES BEGGS
Rochester, N. Y.



For pinions with a small number of teeth, actual length of contact may be less than the length e_1 e_2 given by usual formulas

Length of Gear Tooth Contact

● *To the Editor:*

The Reference Book Sheet "Chart for Number of Teeth in Contact," on page 359 of the September Number gives incorrect values for certain ratios using pinions with a small number of teeth. Also, on the chart the expression $C \sin \alpha$ was incorrectly given as $C \cos \alpha$. The formula is correct only when the length of contact e_1e_2 in Fig. 1, lies between the points a_1 and a_2, the extreme limits of the line of action. Therefore, the chart is correct only for gearsets consisting of 13 tooth pinions with gears of 13 to 16 teeth, 14 tooth pinions with gears of 14 to 26 teeth, 15 tooth pinions with gears of 15 to 45 teeth, and gearsets with pinions of 16 teeth and more.

When the point of tangency of the line of action with the pinion base circle, point a_1 in Fig. 2, lies inside of the gear addendum circle, the actual length of contact is shorter than the length of contact e_1e_2 given by the formula on the chart. Therefore, the number of teeth in contact is less than that given by the chart.

When the points of tangency lie between the points e_1 and e_2, as in Fig. 3, the length of contact equals a_1 a_2. This length also is shorter than that obtained from the chart. This applies to a gearset with both pinion and gear of 12 teeth.

Actually, the length of contact in gearsets with pinions having undercut teeth is even less than that given above, because the undercut starts above the base circle. The first point of contact then, will be at a point which is the intersection of the undercut circle with the line of action. This point lies between a_1 and the pitch point. Therefore, the length of contract is shortened and the number of teeth in contact is reduced.

—C. A. JOHNSON
Springfield, Mass.

● *To the Editor:*

Buckingham's formula, which reads *sine* where *cosine* incorrectly appeared in the chart, is limited by the statement, "No involute action, however, can take place below the base circle." Therefore, the chart for gears of equal addenda should not have included gears or pinions of twelve teeth. A qualifying statement should have accompanied the chart as follows: "The maximum numbers of teeth in contact that are obtainable with pinions of 13, 14 and 15 teeth are 1.474, 1.542 and 1.610 respectively."

The chart for long and short addenda gearsets is correct but the formula should read *sine* instead of *cosine*.

—F. V. TARBELL
Erie, Pa.

Lighter Than Stated

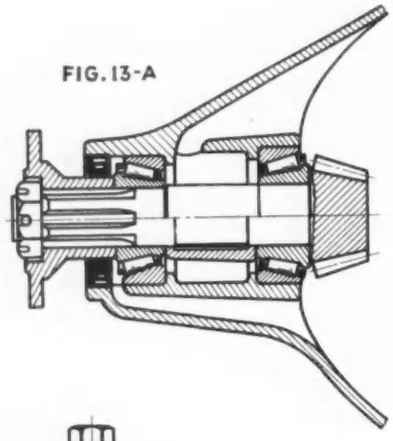
● In the caption under the picture of the "kitchen of the future" which appeared on page 329 of the September number, the last sentence reads, "They weigh only 65 per cent as much as comparable cast-iron fixtures and are finished in color."

The newly developed line of drawn-metal porcelain-enamelled plumbing fixtures designed by Briggs Manufacturing Company weigh 65 per cent less than comparable cast-iron fixtures. To put it another way, their weight is about one-third that of the cast-iron fixtures.

Anti-Friction Bearings

E. WOOLER
Chief Engineer, The Timken Roller Bearing Company

FIG. 13-A



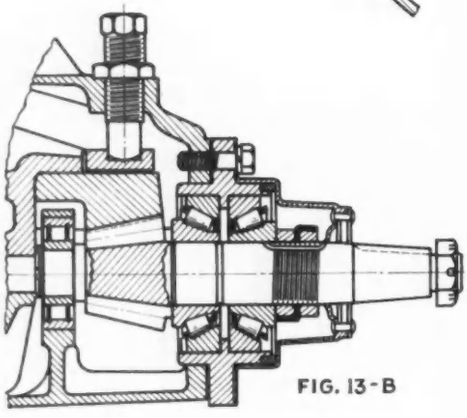


FIG. 13-B

THE severest automotive bearing application is considered to be at the rear-end driving pinion, because the pinion runs at engine speed and in addition to radial loads it imposes heavy thrust loads on the bearings in both directions. Two types of pinion mountings are the overhung and straddle designs.

Fig. 13-A—The overhung type of pinion mounting is used more extensively than the straddle type primarily because the design lends itself well to high production manufacturing methods and is not affected so much by slight variations in machine work. A liberal bearing spread is desirable to minimize pinion deflections.

Fig. 13-B—The straddle type pinion mounting is in principle more rigid than the overhung type, but restrictions limit the size and capacity of the inner bearing. Diameter of the differential must necessarily be small to avoid an excessively large ring gear.

Fig. 14—In the Hotchkiss drive a large single-row and a smaller double-row ball bearing are used on the pinion shaft. The double-row bearing takes all the thrust in both directions and the large bearing floats axially. Pinion adjustment is by a threaded sleeve which is locked in place by a pin that engages the slots in the sleeve.

Fig .15—Separate bolted-on pinion sleeve with shim adjustment, as used on heavy-duty truck and bus axles. A spacer is used between bearing cones, cones being clamped solidly to pinion shaft.

Fig. 16—An older type of overhung pinion mounting with sleeve threaded for pinion adjustment. Double adjusting nuts on pinion shaft give desired preload on bearings. Combination key and clamp holds sleeve in position after pinion adjustment.

Fig. 17—In this type of mounting the pinion is adjusted by the double adjusting nuts located between the bearing caps and accessible from outside. To adjust bearings, nuts are turned separately. Bolts on the outside of housings are then tightened.

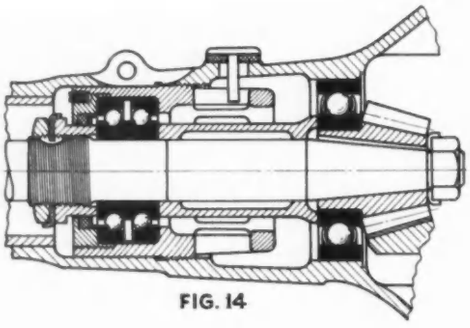


FIG. 14

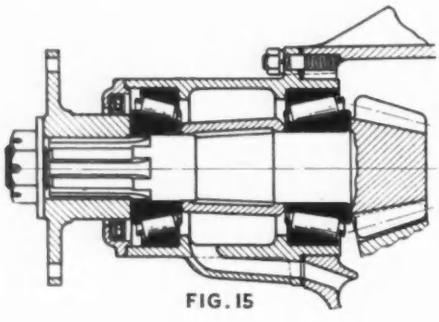
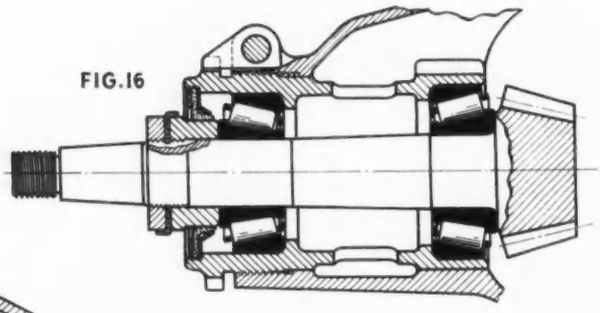


FIG. 15

FIG. 16



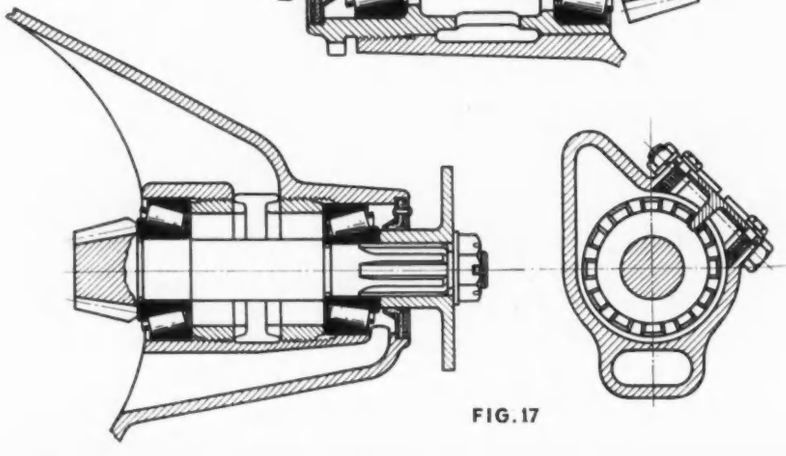


FIG. 17

in Automobiles–II

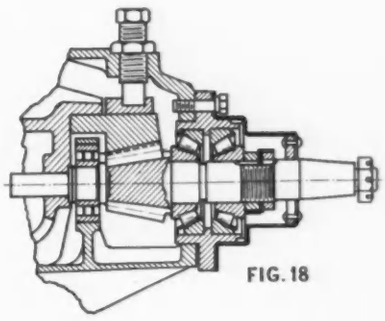


FIG. 18

Fig. 18—A design for a straddle mounted pinion using a straight roller bearing at the inner position. The tapered bearing nearest to the pinion carries the thrust load for forward drive. Caps are pressed into the retainer which is bolted to the differential carrier. Shims provide proper setting of the pinion while the bearing adjustment is made by means of the nuts on the pinion shaft.

Fig. 19—Double-row ball bearings used on each side of a hypoid pinion. Outer bearing is mounted in a sleeve, shim adjusted to locate pinion position. Inner bearing floats in a support tied to the carrier by suitable ribs.

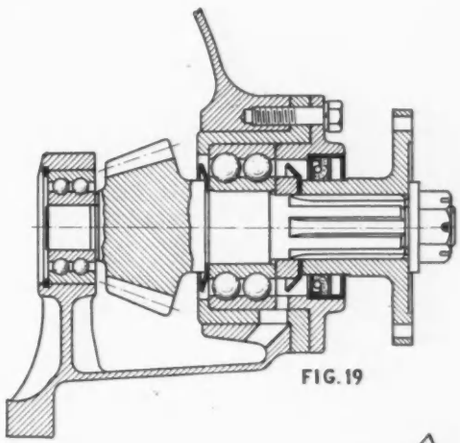


FIG. 19

Fig. 20—In this design the tapered roller bearings are mounted in a double cup with no provision for pinion adjustment. The initial bearing adjustment is obtained by making the length of the spacer between the bearing cones to suit. The inside bearing is of the straight roller type without an inner race.

Fig. 21—In this double reduction axle using herringbone gears for the final drive, the positions of the pinion and cross shafts are adjusted by the bearing shims, thereby fixing the position of pinion and ring gear. Adjustment of the bevel gear also fixes the location of herringbone pinion. Ball bearings on rear axles float in their support, herringbone bull gear finding its own center.

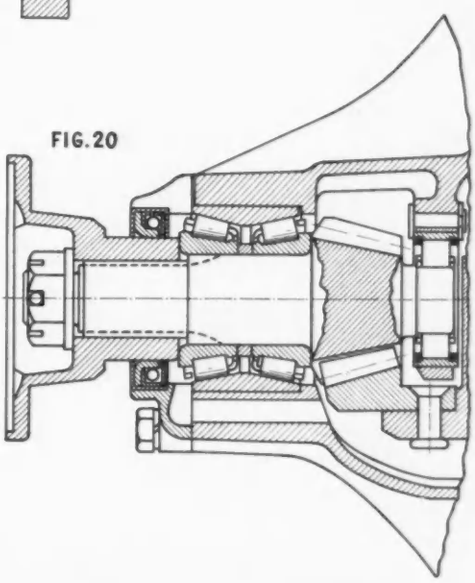


FIG. 20

Fig. 22—An overhead worm drive construction used for trucks and buses, wherein the wormshaft at the rear is mounted on tapered roller bearings of the steep-angle type. The bearing nearest to the worm carries the thrust load for forward drive, being adjusted by the double nuts. The front end of the wormshaft is mounted in a straight roller bearing to allow for expansion.

Fig. 23—In the underslung worm-driven axle, the forward larger bearing of the wormshaft takes the heavy thrust of the drive. The two bearings can be placed closely together, this being made possible by the small diameter of the worm gear. Worm gear differential bearings are usually larger than the bevel ring gear differential bearings because the side thrust on a wormwheel is greater than that on a corresponding spiral bevel gear.

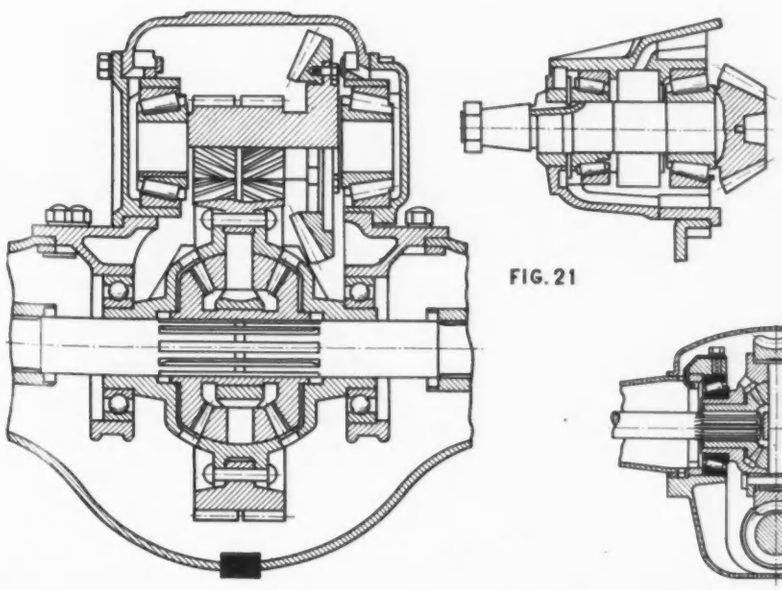


FIG. 21

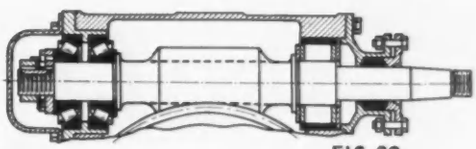


FIG. 22

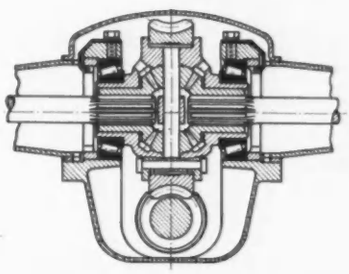
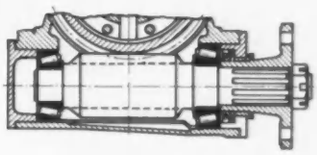
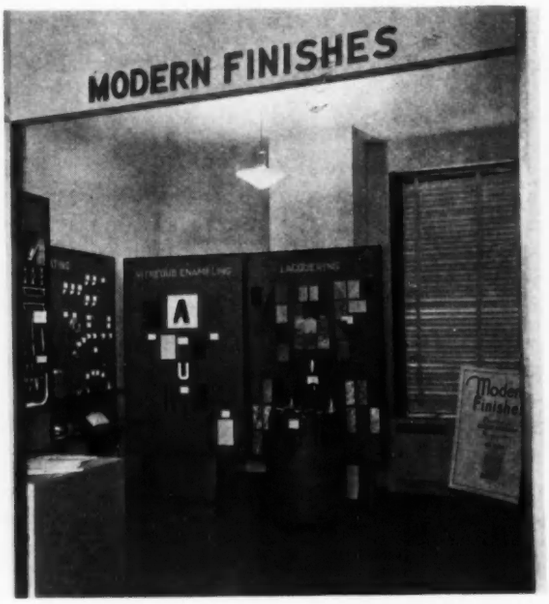


FIG. 23



NEWS

Metal and Plastics Exhibit Opens in New York



One of the numerous alcoves wherein are exhibited metals, plastics and finishes in attractive surroundings

WITH suitable ceremonies, the Metal Products Exhibit—the first permanent exhibition of metals and plastics in this country—opened its doors on September 16, in the International Building, Rockefeller Center, New York. This permanent exhibit, which is under the direction of Metal Products Exhibits, Inc., is designed to provide a comprehensive review of metallic and plastic materials and parts as used by industry.

Features at the opening of the exhibit included a display of "Metals in the Modern Manner," by a group of industrial designers; an exhibition showing metal finishing in all its phases; and a comprehensive display of modern plastics as parts and finished products.

The entire third floor of the International Building, comprising 16,000 sq.ft. of floor space, has been reserved for exhibition purposes, but only a part of this space is at present ready for occupancy. A large reception room also serves as a "gallery" for special exhibits and as an auditorium for meetings of associations interested in industrial materials. Beyond, is the exhibition area, containing wall panels, booths, rooms, and other exhibition facilities. The simplicity of the decorative scheme of the exhibit is striking. All walls and exhibit spaces are finished in a light neutral tone, without decorative detail. By contrast, the brilliancy of the metals and finishes on display is greatly enhanced.

Noteworthy items in the exhibition of modern industrial design include: cocktail set, tea set and folding tray by C. J. Ackerman; trestle table by Buoy, Inc.; tables by Donald Deskey; alarm clocks and kitchen utensils by Henry Dreyfuss; console table by Frank W. Gratz; refrigerator, washing machine and coffee set by Lurelle Guild; ash stand and coffee table by Allen Gould; door knob and switch plate by Gustav Jensen; lamp, salt and pepper shaker and penholder by William Lescaze; occasional table, cocktail shaker and coffee set by Paul A. Lobel; electric locomotive model, refrigerator and cosmetic compact by Raymond Loewy; clocks, water cooler and reflector lamp by Gilbert Rohde; oil heater, gas range and sales slip register by Walter Dorwin Teague; chafing dish, book ends, and cigarette box by Walter Von Nessen; and coffee set, punch set, and smoking set by Russel Wright.

Reception room at the Metals Products Exhibit at Rockefeller Center, which also serves as an auditorium for holding meetings of technical societies

Numerous examples of straight polishing, electro-plating, chemical coloring, rust proofing, lacquering and enamelling, and vitreous enamelling are included in the exhibition of modern metal finishes. Among the manufacturers contributing to this exhibition are Aluminum Company of America, Egyptian Lacquer Company, Graselli Chemical Company, Hanson-Van Winkle-Munning Company, Lea Manufacturing Company, Mass and Waldstein Company, Morris Sanders, Parker Rust Proof Company, Pyrene Manufacturing Company.

Molded phenolics, ureas, and combination products, cold molded parts, cast resins, and laminated materials are exhibited by 17 companies.

Metals Exposition Bigger Than Ever

MORE than 35,000 interested visitors are expected to be in Chicago during the week beginning September 30, to attend the National Metals Exposition to be held in the new International Amphitheatre. The exposition will be open every day from 12 noon to 10 p.m. The entire space of the huge Amphitheatre, more than four acres, will be devoted to manufacturers' displays.

The exposition management has announced that this year's exposition is already 30 per cent larger than that of last year; more than 200 companies having reserved exhibit space. It is anticipated that this will be the largest metals show ever held. In addition to metals, alloys and metallurgical instruments, there will be exhibited welding equipment, metal spraying equipment, heat-treating equipment.

Zinc Plating Process Gives Bright Finish

A NEW electro-plating process which deposits a bright zinc surface on steel articles has been announced by E. I. duPont de Nemours & Company, Inc., Wilmington, Del. It is claimed that this new process makes possible, for the first time, a bright plating of zinc.

In announcing the new process the company states that it was developed to make available an economical method of making steel rustproof while, at the same time, giving it a bright appearance. It is stated that many tests of this new process have been conducted in large commercial plants and that it will be publicly demonstrated for the first time at the National Steel Show in Chicago, September 30 to October 4, inclusive.

Among the uses claimed for this new process are included the plating of automobile parts and accessories, household appliances and equipment, hardware, screws and fittings, steel stampings, and similar parts. One feature claimed for the process is that it will enable the economical production of decorative surfaces with good corrosion resistance on steel.

Machine Tool Show Amazes All Visitors

MACHINE TOOL builders sprang a big surprise at the Cleveland Show, September 11 to 21. During the six years since their last exhibition their designing engineers have not only been busy but have been "going places." A glance at the 1935 models at the show proves it, but to attempt to describe the impressions created by the vast array of machinery on exhibiton would be futile.

Weeks would be required to make a thorough inspection of the 900 machine tools packed into the 5 acres of exhibition space. Two-thirds of the machines were in operation, at times requiring a total of 6,000 hp. to drive them. Here was $3,000,000 worth of machine tools exhibited by 120 of the leading machine tool builders, added to which were the displays of 110 manufacturers of accessories and parts.

Easier operation, faster and more accurate production were the significant features of the new machines. Here was a huge milling machine that through hydraulic control required only the push of a finger to move the head or bed in exact unison with the control wheel; a lathe with hydraulic gear shifts; and a screw machine that produced a threaded brass fitting in a second as compared to 3 seconds in the older model. Variable-speed drives enabled machines to be run at the most effective speed. A new design of planer was cutting in both directions; another planer attracted great attention because of its completely electrical control and operation. Torque motors were operating chucks and doing similar tasks formerly done manually. A 4-spindle automatic screw machine was turning out shouldered screws with a tolerance of 0.0003 in. on the diameter of the shoulder. To describe everything would take a book.

Returning from the show, the production manager of a general manufacturing company was dubiously shaking his head. Asked why, he answered, "If I can't convince our vice-president to buy new machine tools, I'll be out of a job because we won't be able to compete against our competitors who have these new machines." The answer was, "Send him to the show, he'll buy."

Exactly that was happening at the show. Machine tool salesmen sat down to supper with cheerful grins. Numerous sales were reported; many excellent prospects expressed their intentions to buy. One manufacturer estimated that he would have to buy $100,000 worth of new equipment. The machine tool industry is now cashing in on its engineering activity over the past years.

EDITOR'S NOTE—Editorial staff members of *Product Engineering* were in constant attendance at the Machine Tool Show, interviewing chief engineers and recording the salient developments and trends in the design of machine tools. The data and information obtained will be incorporated in the Product Development Survey Report to appear in the November number.

MEETINGS

American Gear Manufacturers Association—Semi-annual meeting, General Brock Hotel, Niagara Falls, Canada, Oct. 14-15. J. C. McQuiston, secretary, Penn-Lincoln Hotel, Wilkinsburg, Pa.

International Acetylene Association—36th annual convention, Cleveland Hotel, Cleveland, Ohio. Nov. 12-15. H. F. Reinhard, secretary, 30 East 42nd St., New York, N. Y.

EXHIBITIONS

National Automobile Show — Grand Central Palace, New York, N. Y., Nov. 2-9. Alfred Rieves, manager, 366 Madison Ave., New York, N. Y.

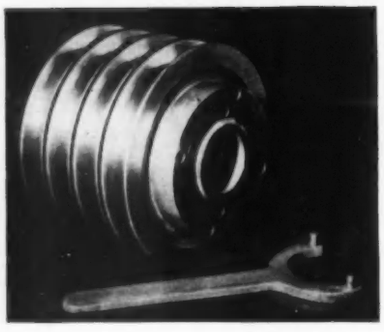
Exposition of Chemical Industries—Grand Central Palace, New York, N. Y., Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

Heating and Ventilating Exposition—International Amphitheatre, Chicago, Ill., Jan. 27-31. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

New Materials and Parts

Vari-Pitch Texrope Sheave

Can be adjusted to give speed variations as high as 25 per cent. When both sheaves of a drive are of this type, the range of variation is increased correspondingly. Made in two multi-groove types—stationary and motion controlled. The former is used when occasional changes are required, and the latter is used where frequent quick changes within the full range are required while the drive is in operation. Allis-Chalmers Mfg. Co., Milwaukee, Wis.



Anti-Friction Bearing Caster

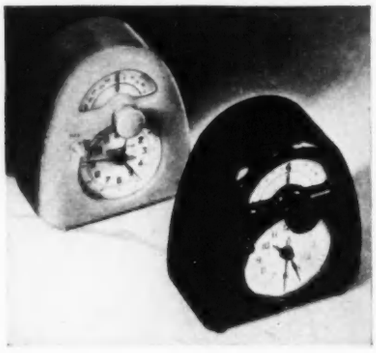
Heavy duty "Forge Weld" caster for swiveling and non-swiveling applications. Drop forged of S.A.E. 1045 steel. Raceways for $\frac{3}{8}$ and $\frac{1}{2}$ in. diameter balls are precision machined, Alemite equipped. Bolt and nut assembly throughout for bearing adjustment. Wheels are mounted on Hyatt or Timken roller bearings and made of nickel-steel-iron or Textolite or are rubber tired. Each metal or Textolite wheel has capacity of 1,500 to 2,000 lb., and 450 to 550 lb. for rubber tired wheels. Sizes available for 5, 6, 7, 8 and 10 in. diameter wheels with $2\frac{1}{4}$ to $2\frac{1}{2}$ in. offset. Service Caster & Truck Co., Albion, Mich.

Oil-Proof V-Belt

For use on machine tools and other installations where excessive oil conditions exist. The "Daycoil" V-belt, made of synthetic rubber, has the same laminated construction principles as the regular Dayton Cog-Belts. It is said to have flexibility, resiliency and good abrasion resistance and wearing qualities. Dayton Rubber Mfg. Co., Dayton, Ohio.

Solderless Cable Terminal Lugs

Are neither castings or forgings but are made by a special "cold flow" process making it possible to use pure electrolytic copper. This process is said to assure high conductivity and to increase the mechanical strength to withstand the clamping of the wires necessary for a good contact. By having a through hole, better visual evidence of a proper contact is possible. Only 5 sizes are necessary to cover the entire range of wires and cables from No. 14 to 1,000,000 CM. On all but the smallest size, socket head set screws are used. Bull Dog Electric Products Co., 7610 Jos. Campau Ave., Detroit, Mich.

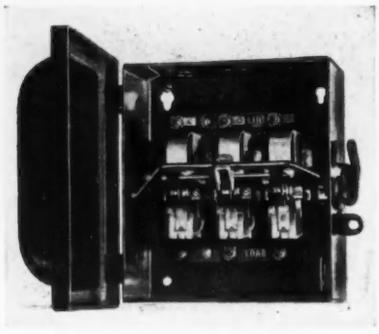


Interval Timer

For precision timing, this "Measured Time" electric interval timer is used for engineering and chemical requirements. A large diameter "interval dial" times periods from 1 to 120 min. while the clock, with a large red second hand, indicates fractions of a minute. A clear-toned buzzer may be adjusted for loud or soft, long or short. Molded bakelite case has high dielectric strength and is acid resisting. Available in a number of colors. Furnished for 110 volts, a.c., 60 cycles. Measured Time, Inc., LaPorte, Ind.

Circuit Breaker

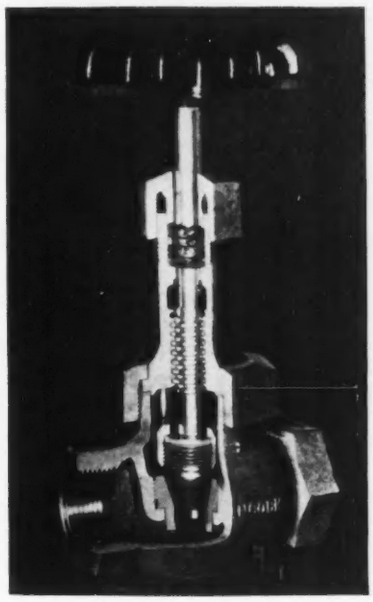
The overload element of the "Re-Cirk-It" circuit breaker is electromagnetic with time delay controlled by a hermetically-sealed unit. The circuit breakers are manufactured with different time current curves, and the breakers are then matched against the particular circuit characteristics. It is said that this method assures accurate protection; that the tripping point is unaffected by ambient temperature; and that the magnetic trip time delay provides delayed trip on overloads and



high speed trip on short circuits. Furnished in closed steel boxes or in bakelite housings. Available for 1, 2, or 3 pole, 250 volts a.c., ½ to 35 amperes. Heinemann Electric Co., Trenton, N. J.

Globe and Angle Valves

Have stainless steel valve disks and seat rings hardened to 500 Brinell. Said to prevent wire drawing, steam cutting and galling. Disk is attached to stem in such a way as to facilitate regrinding. Special bronze, claimed to lengthen service life, is used for stem and bonnet. Can be replaced while



valve is in pressure service. Available for services up to 300 lb. per sq. in. pressures. The Hancock Valve Co., 93 Elias St., Bridgeport, Conn.

Free Cutting Alloyed Aluminum

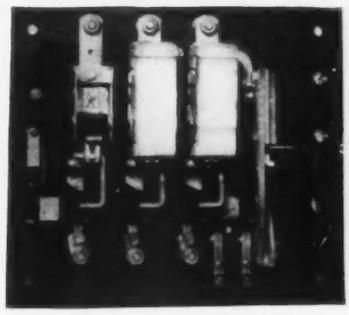
For easy machinability in automatic screw machines, two types of alloyed aluminum are available, one with magnesium content and one without, each having two tempers classified as T and W. The T tempered material has tensile properties approximately the same as free-cutting brass, and has high yield and shear strength with slightly lowered impact resistance. In the W tempered material high strength and toughness are obtained, although the material is relatively soft. It is said to have excellent machining qualities and can be cold worked. Aluminum Company of America, Pittsburgh, Pa.

"Sure Flow" Pump

For coolants, water, oil or fluids that are charged with abrasive. Said to maintain their prime without submerging part of pump in the fluid. Available for low and high pressures and supplied with horizontal or vertical base for upright or wall mounting. Belt drive models can be had for 4, 10, 20, 50 and 100 gal. per min. capacities. Direct motor drive models available in 10, 20, 50 and 100 gal. per min. capacities. The Acme Machine Products Co., Inc., Muncie, Ind.

De-ion Contactors

Suitable for built-in use, the 100 and 150 amp. De-ion contactors are said to have a high-rupturing capacity, and are compact, of shock-proof construction, quiet operating and can be connected front and back. Have a rolling and sliding contact on closing with a high contact pressure. Shields confine arc flame so that electrical clearance around arc members can be reduced to a minimum. Quenching members said to provide high interrupting capacity, long contact life for frequent operation and large safety factors on overloads. Contactors utilize E-type magnet with vertical armature travel. Jarring and bumping cannot cause accidental closing. All



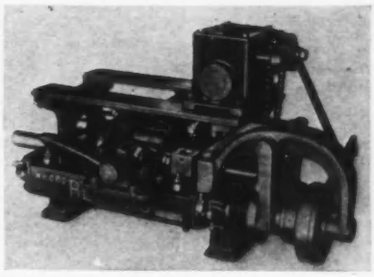
parts accessible from front. Can be mounted on steel base or panel material. Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

Cast Iron Enamels

A new series of lead-free vitreous enamels for cast iron are said to be an exact match in whiteness for sheet iron enamels. Previously there had always been a distinct difference between shades of white for porcelain enamels fabricated for cast and sheet iron. The enamel formerly used on cast iron usually showed yellow or gray and did not have the opacity of sheet iron enamels. It is said that these new enamels for cast iron are more workable and do not require special treatment. The Porcelain Enamel & Mfg. Co., Baltimore, Md.

Automatic Variable-Speed Ratchet Control

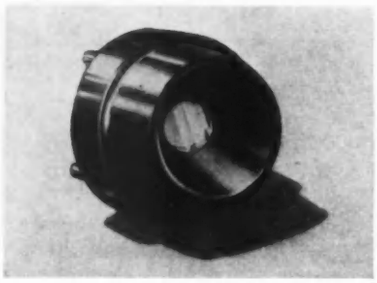
The power input shaft of the variable-speed transmission can be driven by motor, line shaft or engine,



and drives a gear reducer of proper ratio by a roller chain. The output shaft of the reducer is connected by an adjustable arm to the ratchet which is mounted on an extension of the speed changing screw of the transmission. When the speed range required over a fixed period of time is known, the ratchet can be set so the transmission begins operation at either extreme and finishes at the other extreme. In the application shown the variation is only 83 r.p.m., or 3⅛ turns of the speed changing screw in 11 hr. The transmission is then shifted by hand back to the starting speed position and the ratchet reset by the lever. Reeves Pulley Co., Columbus, Ind.

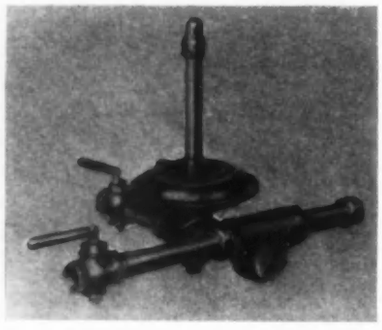
Electric Eye

Photo-electric cell consists of two metal electrodes hermetically sealed in a bakelite case. Said to be unaffected by continuous exposure to light but to react to both the intensity and frequency of the incident light rays and to be entirely electronic in action. Can be used as a component part in suit-



able circuits to operate relays, deflect sensitive meters, or when connected to the input of a vacuum tube amplifier to perform operations which are accurately completed in 1/10,000 sec. Operates on a.c. or d.c. and is available either singly or in complete assemblies containing cells, relays, tubes, resistances or sockets. Hugh H. Eby, Inc., 2066 Hunting Park Ave., Philadelphia, Pa.

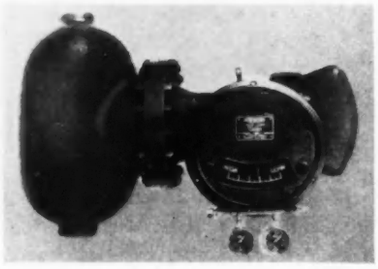
Proportional Mixer



For maintaining constant gas-air ratio in burner applications where close control of atmosphere is necessary for combustion efficiency. Consists of a diaphragm-actuated control valve that feeds gas at atmospheric pressure to an inspirator into which the gas is drawn and mixed with air. The governor is said to be responsive and lag-free, simple to operate and easily adapted to automatic control. Ratios are varied by manual operation. The Philadelphia Drying Machinery Co., 3351 Stokley St., Philadelphia, Pa.

Ball Float Level Stabilog

Maintains a level in a chamber within safe limits and said to provide a smooth out-flow without creating upsetting surges when sudden increases in input occurs. A friction-free ball float mechanism is counterbalanced by movable weights to insure maximum accuracy. Can be installed with ball-float inside the pressure vessel or on



the outside of a kidney type float chamber. The mechanism employs knife-edge bearings. The Foxboro Co., Foxboro, Mass.

"Yoloy" Steel

Nickel-copper alloy steel for resistance to corrosion. Said to have high tensile strength combined with ductility, workability and weldability. Can be hot or cold formed. Made in two series, the low strength series having a tensile strength of 74,000 lb. per sq. in., and the high strength series having a tensile strength of 92,000 lb. per sq. in. Available in sheets, strips, plates, bars, shapes, wire and seamless pipe. Youngstown Sheet & Tube Co., Youngstown, Ohio.

Metering Pump

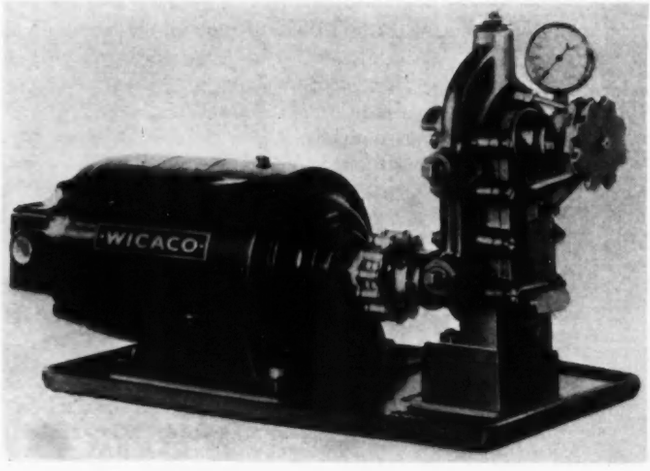
Two-stage adjustable type for light commercial and industrial oil burners, does not require regulating valves, Venturi tubes or viscosity controls. When solenoid or mechanically operated shut-off valves are used, pump is equipped with adjustable by-pass to prevent building up high pressures when burner is slowing down after the valve has been shut off. The pump operates at 200 r.p.m. through a reduction gear unit. Constant flow is provided regardless of oil temperature, pressure or viscosity. Available in various capacities with or without electric drive. Wicaco Machine Corp., 4801 Stenton Ave., Philadelphia, Pa.

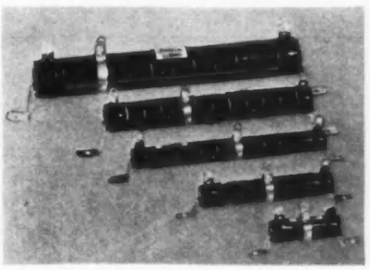
Industrial Thermometer

"Ideal Tel-Temp" is for quick and accurate determination of temperature of motors, generators, bearings, air compressors, centrifugal pumps and other appliances. Dial plate is mounted in dustproof aluminum case and protected with a non-breakable crystal and chromium-plated cap. Has graduations of 0 to 100 deg. C. on a colored background for indicating safe, caution and danger zones. Fastened to machine frame with escutcheon pins and is sealed by flexible rubber ring exclude draughts. Ideal Commutator Dresser Co., Sycamore, Ill.

Semi-Variable Resistors

These Dividohms are wire wound and vitreous enameled with a narrow strip left bare along one side on which contact is made by a ball-point on the adjustable lug. Point contact makes

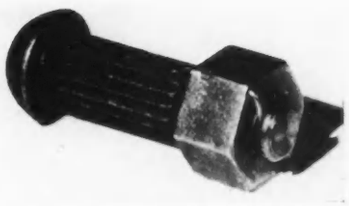




possible the use of several lugs on one resistor without shorting out much resistance. Can be used as small motor controls, radio bleeder and replacement resistors, voltage dividers, lamp dimmers and for obtaining odd resistance values. Available in ratings of 30, 55, 75, 100 and 200 wats with numerous resistance values from 1 to 100,000 ohms. Ohmite Mfg. Co., 636 N. Albany Ave., Chicago, Ill.

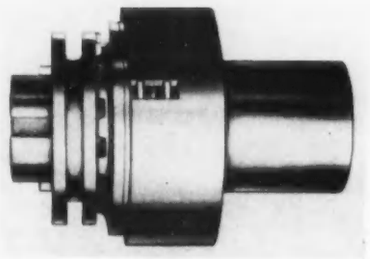
Phenolic Molding Material

Known as "Durez 2260K Black," this material is used for instrument cases, adding machine housings, typewriter parts, and boxes and containers that must withstand rough usage. Said to have an impact strength approximately 33 per cent greater than the average compounds. Has a compressive strength of 29,000 per sq.in., a heat resistance of 400 deg., F., and weighs 22.2 grams per cu.in. Excellent finishes are also claimed for this material. General Plastics, Inc., North Tonawanda, N. Y.



Structural Rib Bolt

With an "Anco-Nut," this bolt is used where a tight fit in the bolt hole is required or as a substitute for a rivet. The triangular shaped ribs are made 3/32 in. larger than the nominal bolt diameter and are embedded in the wall of the bolt hole when driven in with a hammer. Made of carbon-manganese steel with a tensile strength of 70,000 lb. per sq. in., bolts have standard button heads. Sizes of $\frac{3}{8}$ to 1 in. diameter and 1-1/16 to 5-5/16 in. long are available. The nut is constructed with a locking pin to prevent loosening of the nut without a wrench. Automatic Nut Co. Inc., Chrysler Bldg., New York, N. Y.



Small Clutches

Can be operated singly or doubly either dry or in oil. Design is the same as larger sized clutches except that the angle of actuation has been adapted to conserve frictional area and to strengthen the carrier. Have hand adjustment for wear. Fastened to shaft by set screw or key and set screw. Three sizes available, single plate clutches for fractional hp., and multiple plates for heavier drives; $3\frac{1}{2}$, $4\frac{1}{2}$ and $5\frac{5}{8}$ in. outside diameter. Conway Clutch Co., 1536 Queen City Ave., Cincinnati, Ohio.

Copper-Nickel-Molybdenum Steel

Has a combination of high strength, ductility and resistance to atmospheric corrosion. Because this "Double Strength" steel has an exceedingly tight oxide skin, it is being used for railroad and automotive truck equipment for carrying coal and other corrosion-promoting products. The steel is being manufactured in two grades, grade 1 having a maximum carbon content of 0.12 per cent, and grade 1-A of 0.30 maximum carbon. In both grades the other alloys are the same; manganese 0.50 to 1.00; copper 0.50 to 1.00; nickel 0.40 to 0.80 and molybdenum 0.20 maximum. Physical properties of normalized sheet, strip and plate steel for grade 1 are, yield point 60,000 lb. per sq.in., tensile strength 75,000 lb. per sq.in., and a minimum of 25 per cent elongation in 2 in. For grade 1-A the yield point is 70,000 lb. per sq.in., a minimum tensile strength of 90,000 lb. per sq.in. and a minimum of 18 per cent elongation in 2 in. Said to have little tendency to air-harden so that it can be spot and arc welded. Republic Steel Corp., Massillon, Ohio.

MANUFACTURERS' PUBLICATIONS

Ball and Roller Bearings — The Gwilliam Co., 360 Furman St., Brooklyn, N. Y. Catalog 12, 16 pages, 8½x11 in. Listing roller thrust and journal roller bearings, ball thrust bearings with flat and grooved races, and thrust bearings with levelling plates. Various types of special bearings are shown, and a list of steel ball sizes are given.

Formica—The Formica Insulation Co., Cincinnati, Ohio. Folder "Tires for Factory Trucks," shows tires made of Formica for separate rims and non-separable rims and hubs for rayon, paper, tinplate, and silk mills and soap factories. Range of outside diameters 4 to 12 in. for non-separable rim and hub type wheel and 9 to 11 in. diameter for separate rim type. Also, folder "Pulleys, Bushings and Cabin Lining for Airplanes," giving Formica pulleys equipped with graphite impregnated bronze or corrosion resisting ball bearings. Airplane lining for cabins in sheet form available in 40 colors, also included.

Gear Motors—Allis-Chalmers Mfg. Co. Milwaukee, Wis., Leaflet 2203, 4 pages. Describes eight compact and self-contained speed reducers, with integral or attached motors for low-speed drives mounted either horizontally or vertically. Motors with ratings of 1,750 r.p.m. have various speed reductions from 1,165 to 6.08 r.p.m., from 1 to 50 hp. capacity.

Pressure Reducing Valve — A. W. Cash Co., P.O. Box 135, Decatur, Ill. Bulletin No. 962, 8 pages, 8½x11 in. The "streamlined" principle as applied to this valve to overcome turbulence and obtain a straight flow is described and illustrated with line drawings. Valve is used for air, steam, water or oil. Capacity charts for use with steam, water and air are included.

Pumps, Motors, Transmissions — American Engineering Co., 2440 Aramingo Ave., Philadelphia, Pa. Catalog F, 43 pages, 8½x11 in. Explaining the fundamental principles of Hele-Shaw fluid power with text and diagrams. Photographs and cross section drawings show the construction and method of operations. Numerous types of regulators and various applications are shown. Engineering data relative to hydraulic power, charts of hp. ratings for low and high pressure pumps, and various tables are included.

Resistance Wire—Wilbur B. Driver Co. (formerly Gilby Wire Co.), Riverside Drive, Newark, N. J. Manual, 60 pages, of "Tophet" resistance wire for electrical, radio, chemical, mechanical and automotive industries. Numerous charts and tables pertaining to the de-

sign and construction of electrical heating units are included.

Rotary Blowers—Roots-Connersville Blower Corp., Connersville, Ind. Bulletin 21-B17, 4 pages. Blowers of constant and variable volume or pressure for gas and oil burners, furnaces and ovens, vacuum chucks, pneumatic conveying, air-blast cleaning for motors and machinery, and paper folding machinery or wherever air is to be moved at moderate pressures or equivalent vacuums. Relief valves, air silencers and filters are included.

Stainless and Heat-Resisting Castings—The Cooper Alloy Foundry Co., 150 Broadway, Elizabeth, N. J. Folder illustrating various chrome-nickel iron castings with alloys of selenium, silicon, titanium, molybdenum, copper or tungsten. For use in numerous industries where resistance to corrosion and erosion, wear, creep, deformation and heat are required.

Steel—Edgar T. Ward's Sons Co., P.O. Box 1557, Pittsburgh, Pa. Catalog "Steel-Methods and Materials," 172 pages, 5½x8½ in. Indexed under 10 divisions for steel bars, tubing, strip and flat wire, sheet steels, tool steels, spring steels, spring wire, drill rods, aluminum and general information. Physical and chemical characteristics, heat-treatment, machinability, sizes and tolerances are also given.

Toggle Type Switches — The Hart Mfg. Co., Hartford, Conn., Bulletin No. 17, 14 pages, 8½x11 in. Showing "Diamond H" heater switches as applied to ovens, hot plates, grills, table stoves and electric ranges. Wiring diagrams, dimensioned outline drawings and rating data also included.

Valves—The Fairbanks Co., 393 Lafayette St., New York, N. Y. Catalog No. 21, 52 pages, 6x9 in. Bronze and iron valves showing characteristics and construction in cut-away section photographs. Types included are bronze, plain and regrinding globe and angle valves, gate, check, cross, swing check and sphero valves and Dart unions in various styles. Iron body gate valves with renewable bronze threadless seat rings are included. Range of sizes and working pressures for all types given and a page on the care of valves is included.

V-Belt Drives—The Gates Rubber Co., Denver, Colo. "Complete Guide for Selecting or Designing V-Belt Drives," 48 pages, 8½x11 in. Simplified engineering manual, so written that any drive can be completely designed and delivered price determined from one text. One section outlines an easy method of checking tensions and discusses the effects on V-belt of oil water, steam, dust and chemical fumes. Information not previously published is contained in sections on the care, maintenance, tension adjustment, service conditions, conversions and "flywheel effect." Instructions for design of V-V-belts, quarter-turn, double-V, and V-flat drives are also included. A section of 10 pages lists pulley specifications for various sizes of belt sections.

BOOKS AND BULLETINS

Machine Designer's Guide

Kasimir W. Najder. 198 pages, 5½x8 in. 265 illustrations. Green cloth board covers. Published by Edwards Brothers, Inc., Ann Arbor, Mich. Lithographed. Price $2.50.

A clear and concise book of formulas for reference without the use of higher mathematics. It is intended for daily use by mechanical engineers, machine designers, draftsmen, inventors and technical students. Divided into five sections, the first of 26 pages, contains tables and construction of curves. In section 2, the subject of mechanics includes 33 pages. Some of the more important subjects covered in this chapter are gravity, work, power and energy, horsepower, forces and motions, the mechanical elements, thermodynamics, inertia and torque. Section 3 deals with graphics of forces, center of gravity, bending moments and reactions and bearing pressures. Strength of materials in Section 4 contains strength, stress and weight tables, 16 pages of beam formulas and various spring calculations and tables. In Section 5, there are 38 pages with 45 examples and 36 sketches of practical design problems with a detailed solution in each instance. There are 247 formulas in the book. An index of 10 finely printed pages completes this reference book.

Applied Working Deflection Principles of Helical Spring Design

Walter H. Roe, 82 Liberty St., Tiffin, Ohio, paper covers, 8 pages, 8½x11 in. Price $1.

Charts and tables based upon the working deflection or working range rather than on the total deflection of helical springs. The author takes into consideration both maximum and minimum working stresses, with special emphasis that the minimum stress is as important to the life of the spring as is the maximum deflection. The difference of these two stresses are plotted on a chart for corresponding values of maximum stress. Other charts include correction factors so that they are adaptable to round or square wire of carbon or chrome vanadium steels, and for bronze, brass or Monel metal.

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Thermostatic Bi-metal

The H. A. Wilson Co., 105 Chestnut St., Newark, N. J. Descriptive booklet "Wilco Blue Book of Thermometals," 32 pages, 8½x11 in., paper covers.

This data booklet describes in detail numerous types of thermostatic bi-metals for a varied line of applications which includes uses in automobiles, hearing devices, indicators, scales and measuring instruments, electric clocks, motors, domestic heat appliances, refrigerators, signal devices, time switches and other products in which bi-metal is used. The useful properties of eight thermostatic metals with deflection and force exerted because of temperature changes are tabulated and charted. Temperature deflection curves of eight types of bi-metal are given. Two pages contain the derivation of thermometal formulas.

The Properties of Some Special Bronzes

International Tin Research and Development Council, Technical Publication Series A, No. 18, by D. Hanson and M. A. Wheeler, 20 pages. Copies are available free from L. J. Travener, 149 Broadway, New York, N. Y.

A survey of the experiments in which various elements have been added to copper-tin alloys, other than phosphorus and zinc. Shows the effects of aluminum, manganese, aluminum plus manganese, silicon, and iron on the hot- and cold-working properties of the bronzes, and on the mechanical properties of the rolled products. Some observations have also been made on the microstructures of the various alloys used. Charts, tables and photomicrographs are included.

Stress Concentration at Fillets, Holes and Keyways as found by the Plaster-Model Method

University of Illinois, Engineering Experimental Station, Urbana, Ill. Bulletin No. 276, by Fred B. Seely and Thomas J. Dolan. 34 pages.

The object of the tests recorded in the bulletin was to obtain the information on the reliability of the plaster-model method for determining highly localized stresses. These tests supplement the mathematical method. It is assumed that with certain limitations, the same ratio will hold between load and maximum stress in any member made of elastic and ductile material, such as low-carbon steel, as is found for a similarly-loaded brittle-material member, provided that the stress does not exceed the proportional limit of the ductile material. The booklet contains thirteen photographs and charts of sample pieces, and four tables of physical data.

Chart for Calculating Needle Bearings

CARL P. NACHOD
Vice-President, Nachod & United States Signal Company, Inc.

IN THE preparation of the chart given on the next page, engineers of the Bantam Ball Bearing Company, McGill Manufacturing Company, Roller Bearing Company of America, and the Torrington Company, furnished the criticism and suggestions that form the basis of the following comments and explanations.

All the engineers consulted agree that the formula solved by the chart is "a standard one for calculating the load-carrying capacity of a roller or needle bearing of the given proportions under ideal conditions. Correction factors for service conditions as recommended by the makers should be applied. That is, determination of the load capacity of a needle or quill bearing is a function of variables in addition to the ones considered in the formula and chart. All facts regarding an application should be known before a bearing can be selected for a given service."

Indeed, the formula itself is empirical and is open to question, although it can be safely used in making preliminary calculations. The constant (6,000) has been changed several times over the past few years, for the reason that "there is very limited authoritative data available on the design and mechanics of the so-called needle type bearings, in a large measure, because the unit is, as we consider it today, of recent development."

The principle of the small-diameter roller, full type cylindrical roller bearing is not new, but not much thought was given to it in the days when it was used for toys and farm equipment. However, when consideration was given to the application of that type of bearing to machine tools and other machinery and equipment, it became necessary to make a careful study of the mechanics of its operation.

Various constants have been used in the formula on which this chart is based. In the past, 11,250 and 10,000 have both been used and recommended for determining the safe loads on needle bearings. In some instances the neglect to allow for unusually severe service conditions resulted in the bearings thus calculated failing in service. In order to be on the safe side, the constant 6,000 is used in the formula presented here. This increases the factor of safety. It is considered advisable to use a generous safety factor, particularly since such variables as the life or fatigue limit of the bearing material, misalignment, loss of effective roller length and clearances are not incorporated in the formula.

Alignment is perhaps the most important factor in satisfactory needle-bearing operation, especially where the rotation is at relatively high speeds. This becomes an acute problem as the length of the roller increases. The usual causes of this misalignment are improper machining of the shaft housings, deflections caused by lack of rigidity in the design, and general machining inaccuracies. These should be eliminated as much as possible if the bearing is to operate at its theoretical capacity.

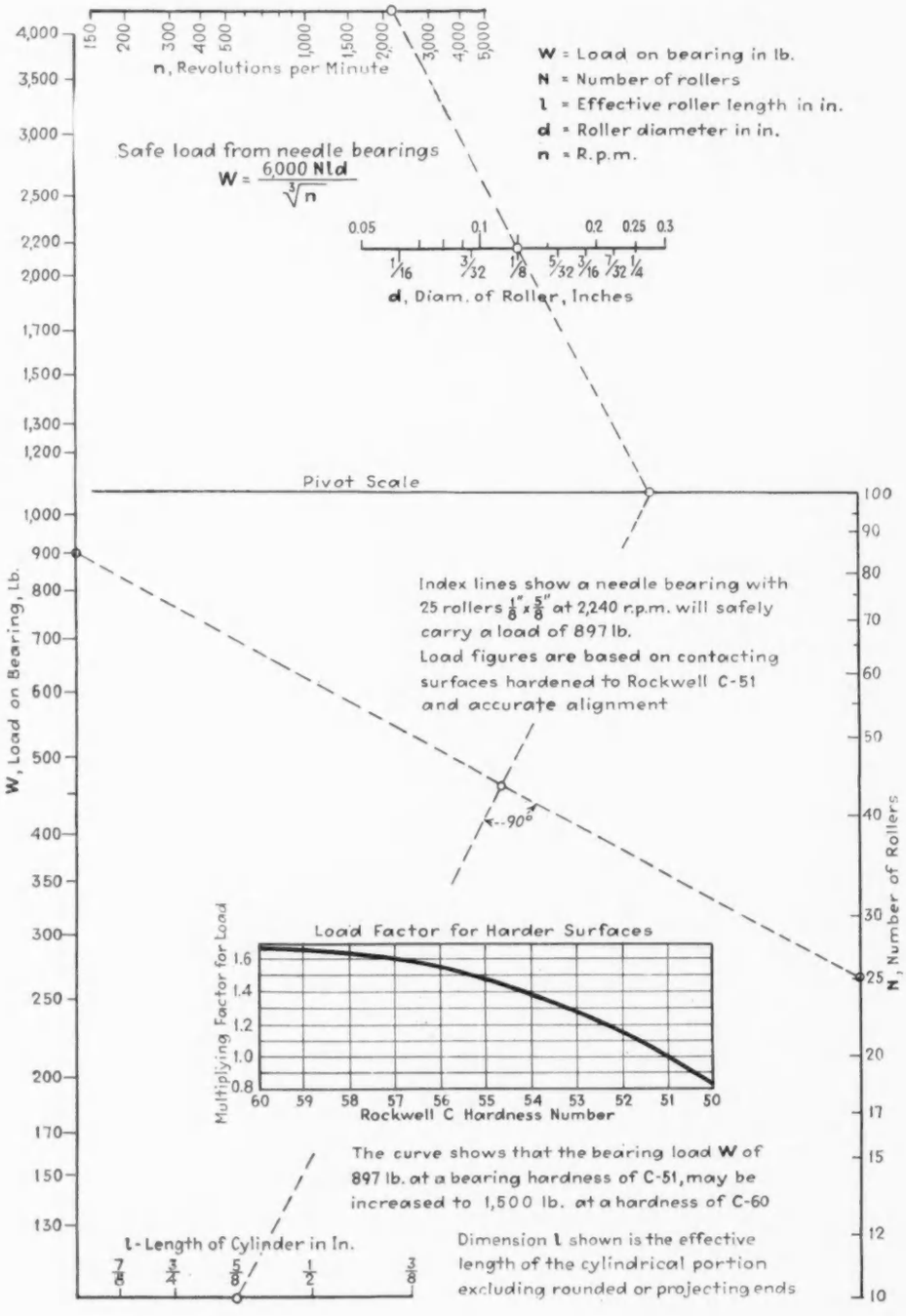
For convenience, the load factor for the variation in race hardness is shown by the curve given on the chart which is taken from the *Engineering Data Book* of the Bantam Ball Bearing Company. By making the calculation as indicated on the chart, corrections can be made for differences in race hardness.

The chart takes into account the difference between total roller length and effective roller length in that all calculations must be made on the net effective length of the roller. The length of the rounded ends, etc., must be deducted from the total length of the rollers. All designs of rollers have a definite loss on the ends.

One factor that is not incorporated in the chart is the life or fatigue limit of the bearings. However, the generous factor of safety by virtue of the low constant used will, for all average applications, provide for a satisfactory life or fatigue limit for the bearing. In the final design it is always best to consult the bearing manufacturer and have the figures checked by his engineering department.

Chart for Calculating Needle Bearings

CARL P. NACHOD
Vice-President, Nachod & United States Signal Company, Inc.


n, Revolutions per Minute
150 200 300 400 500 1,000 1,500 2,000 3,000 4,000 5,000
W = Load on bearing in lb.
N = Number of rollers
l = Effective roller length in in.
d = Roller diameter in in.
n = R.p.m.
Safe load from needle bearings
W = 6,000 Nld / ∛n
0.05 0.1 0.2 0.25 0.3
1/16 3/32 1/8 5/32 3/16 7/32 1/4
d, Diam. of Roller, Inches
Pivot Scale
W, Load on Bearing, Lb.
4,000 3,500 3,000 2,500 2,200 2,000 1,700 1,500 1,300 1,200 1,000 900 800 700 600 500 400 350 300 250 200 170 150 130
N, Number of Rollers
100 90 80 70 60 50 40 30 25 20 17 15 12 10
Index lines show a needle bearing with 25 rollers 1/8" x 5/8" at 2,240 r.p.m. will safely carry a load of 897 lb.
Load figures are based on contacting surfaces hardened to Rockwell C-51 and accurate alignment
90°
Load Factor for Harder Surfaces
Multiplying Factor for Load
1.6 1.4 1.2 1.0 0.8
60 59 58 57 56 55 54 53 52 51 50
Rockwell C Hardness Number
The curve shows that the bearing load W of 897 lb. at a bearing hardness of C-51, may be increased to 1,500 lb. at a hardness of C-60
l - Length of Cylinder in In.
7/8 3/4 5/8 1/2 3/8
Dimension l shown is the effective length of the cylindrical portion excluding rounded or projecting ends

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